Quarterly Bulletin

Vol. 40, No. 4

May
1958

37/A

CONTENTS

ARTICLE		PAGE
40-80	Polyethylene Glycol as an Indicator of Digestibility in Dairy Cows	714
40-81	High Level Urea Feeding to Dairy Cattle II. The Effect of Sulfur Supplementation on the Growth of Dairy Heifers	724
40-82	The Effect of Chemical Structure of Benzimidazoles and Related Compounds on the Growth Inhibition of Plants	728
40-83	Foliar and Soil Applications of Chemicals for the Control of Pink Rot of Celery	734
40-84	Location and Site Selection Factors for Winter Sports Areas in Michigan	740
40-85	Effect of Spices in Feed on Poultry Meat Flavor..	747
40-86	The Effect of Washing Eggs on Hatchability.....	754
40-87	Impact of the "County Agent" Television Film Series	758
40-88	Studies on Muskmelon and Tomato Responses to Polyethylene Mulching	770
40-89	A Study of Malathion for Controlling Flies in Dairy Barns and on Dairy Cattle	786

(Continued on Next Page)

30 JUN 1958

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CONTENTS

(Continued from Outside Front Cover)

ARTICLE		PAGE
40-90	Economics of Growing and Irrigating Pickling Cucumbers	796
40-91	A Test of Combine Varieties of Sunflowers in Wildlife Food Patches	806
40-92	Cucurbit Powdery Mildew Fungicide Trials, 1956-57	811
40-93	Spartan Rock—A New Fusarium Wilt Resistant Muskmelon	822
40-94	Quality Control in Cherry Processing Plants	825
40-95	The Southwestern Michigan Fruit and Vegetable Farm Business, 1957 I. Farm Costs and Returns	838
40-96	Estimating the Average Number of Acres Per Farm in Barry County, Michigan by Two-Stage Sampling	852
40-97	Interrelationships of Furazolidone and other Feed Additives on the Growth of Poultry	857
40-98	The Mineral Content of Corn Grown on a Kalamazoo Sandy Loam Soil as Affected by the Use of Commercial Fertilizer	861
40-99	Thermocouple Errors in Long Wires with Different Types of Insulation in Wet Locations	870
40-100	Leaching of Foliage by Rain and Dew as an Explanation of Differences in the Nutrient Composition of Greenhouse- and Field-Grown Plants	876
40-101	The Effect of Clipping on the Yield of Winter Barley	882
40-102	Correlation of Soil Tests, Plant-Tissue Tests, and Yield Response of Several Crops Grown on Organic Soils	884
40-103	Production in Michigan Blueberry Plantations in Relation to Nutrient-Element Content of the Fruiting-Shoot Leaves and Soil	896
40-104	Relationship Between Nutrient-Element Content of Blueberry Foliage and Fruit	906
40-105	Soluble Solids in Blueberry Fruit in Relation to Yield and Nitrogen Content of Fruiting-Shoot Leaves	912
40-106	Balanced Pruning of the Concord Grape—Another Look under Present-Day Conditions	915
40-107	How Large is the Surplus of Farm Products?	920
40-108	The Evaluation of Pickling Cucumber Varieties for Michigan	932
40-109	Optimum Length of Laying Period and Timing of Laying Flock Replacement	942
40-110	Multiple Purpose Tanks for Michigan Cherry Growers	955
40-111	A New Method for Producing Hybrid Cucumber Seed	960
40-112	Deep Plowing—A Progress Report	966
40-113	The Inheritance of Egg Shell Color in Synthetic Meat Type Populations of Chickens	972
	Journal Article Abstracts	978

THE QUARTERLY BULLETIN

VOLUME 40 • NUMBER 4 • MAY 1958

MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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POLYETHYLENE GLYCOL AS AN INDICATOR OF DIGESTIBILITY IN DAIRY COWS

By L. E. CHRISTIE and C. A. LASSITER[1]

DEPARTMENT OF DAIRY

THE NEED FOR A RELIABLE INDICATOR of digestibility has long existed. For many years, research workers have searched for an inert substance which would pass through the digestive tract in such a manner that digestion coefficients could be determined indirectly through ratio techniques. Recent interest in the measurement of forage digestibility with the grazing animal has increased the significance of indicators in nutrition work.

The shortcomings of many indicators now in use have been pointed out by Van Der Kley (1956). No material has thus far satisfied all the requirements essential for an indicator to give a valid estimation of digestibility.

This experiment was conducted to further evaluate polyethylene glycol as an indicator substance. The use of a water-soluble compound, like this one, as an indicator would seem to eliminate some of the difficulties encountered with insoluble substances which have trouble passing through the digestive tract.

EXPERIMENTAL PROCEDURE

This experiment was initiated to evaluate a wide range of molecular weights of polyethylene glycol (PEG) for use as digestibility indicators. The experiment was divided into two trials. PEG-4,000 (average molecular weight 4,000) was tested in Trial I, using four mature, healthy Holstein cows; A-110, K-239, K-139, and A-71.

[1]The authors express appreciation to Dr. G. L. Crenshaw of the Dow Chemical Company, Midland, Michigan, for supplying the polyethylene glycols used in this experiment and to Dr. J. R. Brunner of the department of dairy for assisting in adapting the determination techniques.

ARTICLE 40-80

In Trial II, cows K-302 and A-71 were used with PEG-6,000; K-239 with PEG-9,000; and K-139 with PEG-20,000.

In both trials, 15 grams of PEG per day were administered orally to each cow with a Balling gun in two gelatin capsules.

Total collection of feces was made in both trials, beginning at the time of the first administration of PEG. In Trial I, total daily collections were made for 16 days and in Trial II for 11 days. Also in Trial I, rectal grab samples were taken from cows K-239 and A-71 at 2-hour intervals for 24-hour periods on the 11th and 13th days of the trial.

Feces samples were stored at 4 to 5° C. until analyzed, with the exception of the total collection aliquots for the first 5 days of Trial I, which were held at -20° C.

Analyses of all feces samples were completed within 2 weeks following the end of the collection period in Trial I, and on the last day of collection in Trial II. Daily total collection aliquots were analyzed for PEG content to obtain an estimate of the recovery of PEG after passage through the digestive tract. The rectal grab samples were analyzed to obtain excretion curves for PEG over the 24-hour periods.

Analyses of PEG content of the feces were made by the turbidimetric metric method of Hyden (1955a). The procedure involves centrifugation of diluted feces samples. Inorganic sulfates in the supernatant liquid were precipitated with an excess of barium chloride and the proteins were removed with barium hydroxide and zinc sulfate. Trichloroacetic acid reagent, containing barium chloride, was added to the filtrate obtained in this manner. The resulting turbidity was measured photo electrically. The only modification of the original method was the use of about 10-gram instead of 1-gram samples of feces.

Since a slight yellow color was observed in the filtrates, absorption and transmission curves were determined with a Beckman Model DK-2 Spectrophotometer. Maximum absorption was observed at a wave length of 300 mu. and maximum transmission at 750 mu. Turbidity was read in a Beckman Model B Spectrophotometer at 750 mu., using a red photosensitive tube with no filter.

In addition to the *in vivo* trials, a series of *in vitro* trials was conducted. To determine if PEG could be quantitatively recovered from biological materials under the analytical conditions of this experiment.

PEG-4,000 was added to dried feces and samples of the dried feces were analyzed for their PEG content.

In another *in vitro* trial, PEG-4,000 and PEG-9,000 were added to duplicate 300-gram samples of slightly diluted fresh feces in Waring blenders. After setting for 5 days with occasional blending, the samples were analyzed for their PEG content.

To determine if PEG was lost in the presence of fecal material, samples of dried feces of various weights were placed in flasks containing aqueous solutions of PEG-4,000 and PEG-9,000, and the solutions analyzed for PEG content.

RESULTS AND DISCUSSION

Solubilities of PEG compounds used in this experiment expressed as percent by weight in water were about as follows: PEG-4,000, 125 percent; PEG-6,000, 90 percent; PEG-9,000, 85 percent; and PEG-20,000, 55 percent. The compound PEG-4,000 (3,000 to 3,700) used by Sperber et al. (1953) was reported 60 percent soluble by weight in water.

Curves plotted from optical density readings on identical concentrations of PEG-4,000, 6,000, 9,000, and 20,000 all fell on the same line. Thus it was considered valid to use the simplified turbidimetric method of Hyden (1955a) for determination of this range of molecular weights. Hyden (1955a) found very similar curves for PEG-4,000 and PEG-6,000 when comparing effects of trichloroacetic acid concentrations.

Hyden (1955a) reported that the slope of the calibration curve was stable. This was true in this experiment with 0.05 to 0.10 mg. per ml. aqueous solutions of PEG until the solutions were 4- to 6-weeks old. At that time, the calibration curve shifted upward. The high stability of PEG in urine reported by Hyden (1955b) was for a 6-day period only.

The yellow color observed in the filtrates was believed to be due to the low feces to water ratio required to attain levels of PEG in the filtrates which could be detected with accuracy. Since Hyden (1955a, 1955b) used large doses of PEG, he probably didn't run into this problem.

In Vivo Recovery of PEG

The recovery percentages of all molecular weights of PEG tested, Tables 1 and 2, were low and approximately within the 40 to 70 percent recovery range reported by Corbet et al. (1956). Recoveries of all molecular weights tested were lower than the 93 percent (82.9 to 102 percent) recovery of single, large doses given cows by Hyden (1955a).

An inverse relationship was observed between the molecular weight of the PEG compound and the percentage recovery. There was no uniform tendency for daily recoveries to increase or decrease as the trial progressed with PEG-4,000; and only between the first and second collection days with the higher molecular weight compounds.

Thus it appears that PEG reached a rapid equilibrium in the digestive tract. However, the daily excretions observed were erratic with no constant day-to-day level of PEG excretion being reached.

The highest feces concentration of PEG attained with the 15-gram

TABLE 1—Percent recovery of polyethylene glycol-4,000 after passage through the digestive tract

	Cow			
	A-110	K-239	K-139	A-71
Day				
1	52.7	62.7	53.1	60.3
2	61.6	57.1	105.5	84.3
3	67.1	89.4	83.9	74.3
4	61.0	114.3	117.3	116.1
5	136.2	80.1	116.9	69.0
6	79.8	80.9	81.5	88.4
7	60.2	93.1	65.1	70.6
8	73.7	96.8	83.3	64.1
9	103.7	92.5	105.9	78.3
10	98.9	69.8	99.3	128.6
11	62.8	69.9	65.4	61.4
12	75.2	85.8	50.4	59.4
13	85.1	96.6	64.5	82.6
14	113.6	62.6	87.3	45.3
15	128.9	54.2	56.9	20.8
16	66.1	61.8	00.0	39.1
Average recovery	82.9	79.2	77.3	71.4
Standard deviation	±25.9	±17.3	±30.1	±26.6

TABLE 2—Percent recovery of polyethylene glycol after passage through the digestive tract

Mol. wt. PEG	6,000	6,000	9,000	20,000
Cow	K-302	A-71	K-239	K-139
Day				
1	24.8	27.1	00.0	00.0
2	57.2	44.1	48.7	43.9
3	55.5	41.2	48.3	38.1
4	38.2	35.9	31.3	45.4
5	114.6	74.2	65.8	76.8
6	51.9	73.2	67.8	54.2
7	51.2	44.8	53.4	48.6
8	48.2	59.4	42.7	46.8
9	62.7	46.9	73.6	38.1
10	69.4	64.9	69.3	53.9
11	110.9	70.4	85.7	54.9
Average recovery(*a*)	66.0	55.5	58.7	50.1
Standard deviation	±26.0	±14.5	±16.5	±11.2

(*a*) Excluding first day's recovery.

daily doses used in this experiment was 0.99 mg. of PEG per gram of fresh feces. Complete recovery was represented by about 0.6 to 0.8 mg. of PEG per gram of feces.

Corbet et al. (1956) reported feces concentrations of 0.55 to 0.8 mg. of PEG per gram of feces when 25 grams of PEG per day were administered. These workers found that increasing feces concentrations of PEG gave increasing, but still incomplete recovery. They suggested a feces concentration of 2.5 mg. of PEG per gram of feces, which would involve the administration of 80 to 100 grams of PEG per day.

Sperber et al. (1953) gave doses of 100 to 500 grams of PEG per day and Hyden (1955b) administered 100 to 200 grams per day to cows. It is believed that these higher levels of PEG might be impractical for use in prolonged studies.

In Vitro Recovery of PEG

The calculated recovery of PEG added to dried feces (Table 3) was assumed to be within the range of experimental error due to the technical difficulties involved in mixing. The results indicate that

TABLE 3—Recovery of polyethylene glycol-4,000 from dried feces

Sample	Percent recovery
1	101.8
2	92.3
3	113.1
4	101.8
5	89.5
6	123.6
Average recovery =	103.7

PEG may be recovered quantitatively from dried feces with the alterations of the method imposed in this experiment.

The incomplete recoveries of PEG-4,000 and PEG-9,000 mixed with fresh feces (Table 4) were very similar to the recoveries of these compounds after passage through the digestive tract. In contrast, Hyden (1955a, 1955b) reported almost complete recovery of PEG added to the feces of cows and sheep. This is also in opposition to the complete recovery of PEG added to dried feces observed in this study.

As shown in Table 5, an essentially linear relationship was found between the weight of dried feces added to aqueous solutions of PEG-4,000 and PEG-9,000 and the weight of PEG removed from the solutions. The amount of removal of PEG from the solutions was directly proportional to the molecular weight of PEG.

TABLE 4—Recovery of polyethylene glycol added to fresh feces

Mol. wt. PEG	Sample	Percent recovery	Percent average recovery
4,000	1a	74.6	78.7
	1b	73.1	
	2a	85.0	
	2b	82.1	
9,000	3a	68.7	66.8
	3b	67.2	
	4a	64.2	
	4b	67.2	

This observation is in agreement with the results with varying molecular weights in the studies on recovery of PEG after passage through the digestive tract and recovery from fresh feces. In both these trials, the recovery of PEG was lower with the higher molecular weights.

TABLE 5—Change in concentration of polyethylene glycol solution with addition of dried feces

Mol. wt. PEG	Dry feces added	PEG/ml.	PEG lost/gm. feces added
	gm.	mg.	mg./ml.
	0	0.104	.....
	0.5	0.102	0.004
	1.0	0.099	0.005
4,000	1.5	0.096	0.005
	2.0	0.094	0.005
	2.5	0.085	0.008
	0	0.104	.....
	0.5	0.095	0.017
	1.0	0.092	0.012
9,000	1.5	0.088	0.011
	2.0	0.085	0.010
	2.5	0.078	0.011

Excretion Curves

The PEG excretion curves (Fig. 1), drawn by plotting concentration of PEG in the feces against time, reveal a definite excretion pattern with the average low concentration of PEG at about 4:00 p.m. and the average high concentration at about 11:00 p.m. The high concentrations observed during the night can partially be accounted for by the higher dry matter content of the fecal samples taken during this time.

Possible Mode of Loss of PEG

The loss of PEG from the solutions with the addition of dried feces could be due either to adsorption of the PEG on the feces or to removal from the centrifugation supernatant in the precipitation process.

Studies in which centrifuged, diluted feces samples were compared with diluted samples which were allowed to sediment without

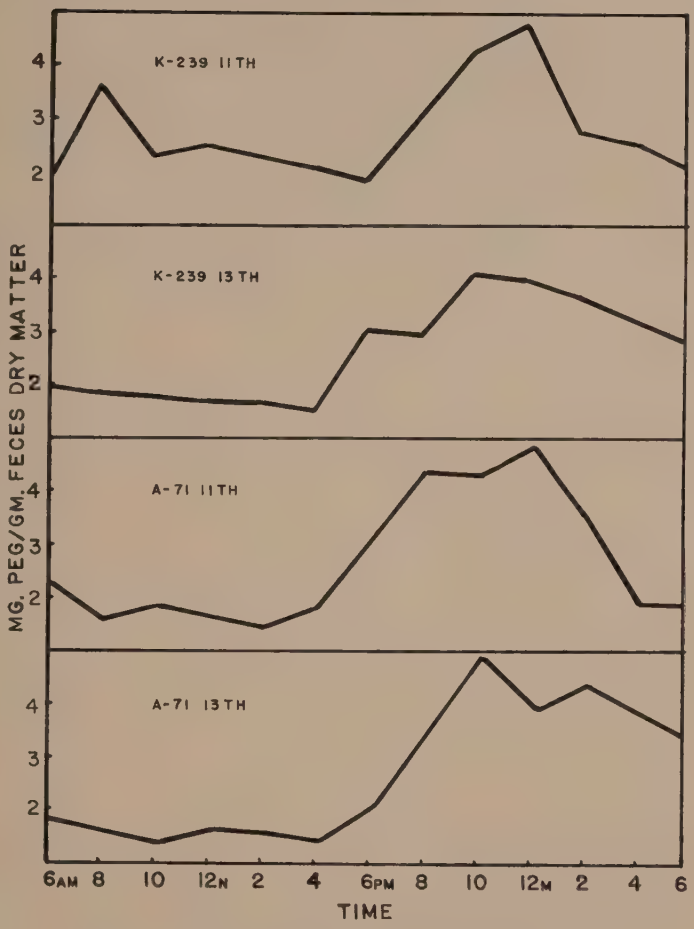

FIG. 1. Excretion curves of polyethylene glycol – 4,000.

centrifugation revealed higher apparent concentrations of PEG in the centrifuged samples. However, due to the smaller amount of foreign material remaining in the supernatant liquid of the centrifuged samples, the differences were not considered conclusive.

On the basis of similar tests with rumen fluid, Sperber et al. (1953) concluded that there was no significant adsorption, precipitation, or uptake of PEG-4,000 by rumen contents.

The possibility exists that PEG was lost in the sulfate-protein

precipitation process; but if this was true, a constant weight of PEG would be expected to be lost. Since very small concentrations of PEG can be detected (Hyden, 1955b), the loss due to this type of interaction could not account for enough PEG loss to explain the low recoveries observed. The high recoveries of PEG from dried feces are also in opposition to this theory.

Since the loss of PEG from the aqueous solutions to which dried feces was added was a function of the weight of feces added, it would seem that adsorption on the feces is the most likely explanation for the loss. Precipitation of PEG with the proteins or sulfates from the supernatant liquid due to adsorption on these components would allow the above linear relationship to hold, as well as adsorption on other feces constituents which would prevent the PEG from being released to the supernatant liquid for analysis. Therefore, it may be concluded that the most likely mode of loss of PEG in the digestive tract is through some type of adsorption on the feces.

The use of large doses of PEG, (Hyden, 1955b and Corbett et al., 1956) would make the losses of PEG observed in this experiment less significant in terms of total recovery of the indicator. This could explain the high apparent recoveries of PEG observed by Hyden (1955b). If the large amounts of PEG did not prove to be prohibitive, the practice of administering large doses might solve the major problems involved in the use of this indicator.

SUMMARY

Eight mature dairy cows on hay-grain rations were used to evaluate the use of polyethylene glycol (PEG) as an inert reference substance in ruminant digestion studies.

PEG with molecular weights of 4,000, 6,000, 9,000, and 20,000 was tested, using the simplified turbidimetric method of Hyden (1955a) to analyze the feces for PEG. Fifteen grams of PEG were administered daily.

Recoveries of PEG after passage through the digestive tract were: PEG-4,000, 77.7 percent (71.4 to 82.9 percent); PEG-6,000, 60.7 percent (55.5 to 66.0 percent); PEG-9,000, 58.7 percent; and PEG-20,000, 50.1 percent.

Excretion curves representing 24-hour periods revealed a definite excretion pattern with lowest concentrations of PEG at 4:00 p.m. and highest concentrations at 11:00 p.m.

Average recovery of PEG added to dried feces was 103.7 percent. When PEG was added to fresh feces, 78.7 percent of PEG-4,000 and 66.8 percent of PEG-9,000 was recovered. Essentially a linear relationship was found between weights of dried feces added to aqueous PEG solutions and weights of PEG removed from the solutions.

The most plausible explanation for the low recoveries observed, in view of the data presented, would seem to be adsorption of the PEG on the feces.

Under the conditions of the present experiment, PEG was not found to be a satisfactory indicator of digestibility.

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HIGH LEVEL UREA FEEDING TO DAIRY CATTLE

II. THE EFFECT OF SULFUR SUPPLEMENTATION ON THE GROWTH OF DAIRY HEIFERS

By C. A. LASSITER, C. F. HUFFMAN, R. M. GRIMES, and C. W. DUNCAN

DEPARTMENT OF DAIRY AND AGRICULTURAL CHEMISTRY[1]

PREVIOUS WORK from this station[2] showed that the growth rate of dairy heifers was quite different when they were fed grain rations in which urea supplied 30, 50, or 70 percent of the total nitrogen. Ground corn cobs were the sole source of roughage. The nitrogen metabolism of the animals did not seem to be disturbed. The possibility of a sulfur deficiency existed since there was a difference in the sulfur content of the rations.

The present study was conducted to test the value of adding sulfur to rations containing high amounts of urea.

EXPERIMENTAL PROCEDURE

Twenty-four Holstein heifers were divided into three groups and fed one of the three grain rations shown in Table 1 for a 120-day feeding trial. Ground corn cobs were the only source of roughage. The management of the heifers was essentially the same as that reported in the previous study.

As noted in Table 1, urea supplied 30, 50, and 70 percent of the total nitrogen in Rations 1, 2, and 3, respectively. Ration 1 contained 0.171 percent sulfur. Sufficient sodium sulfate was added to Rations 2 and 3 to increase the sulfur content of these rations up to about 0.174 and 0.178 percents, respectively. The corn cobs contained 0.027 percent sulfur.

[1]The authors wish to express appreciation to Allied Dye & Chemical Corp., New York, N.Y., for supplying the urea and to Chas. Pfizer Co., Terre Haute, Ind., for supplying the vitamin A used in these studies.

[2]Lassiter, C. A.; R. M. Grimes, C.W. Duncan and C. F. Huffman (1957). High level urea feeding to dairy cattle. I. The effect of high level urea feeding on the growth and metabolism of growing dairy heifers without sulfur supplementation. Journ. Dairy Sci. 41: 281-285.

ARTICLE 40-81

TABLE 1—Composition of experimental grain ration (a)

Ingredients	Rations		
	1	2	3
	(lb.)	(lb.)	(lb.)
Ground shelled corn	1,179	1,436	1,693
Soybean oil meal	600	300	...
Urea	60	100	140
Dicalcium phosphate	120	120	120
Trace salt(*b*)	40	40	40
Vitamins A and D(*c*)	1	1	1
Sodium sulfate	...	3	6
Total	2,000	2,000	2,000

(*a*) Crude protein content of grain ration was 27 percent; urea supplied 30, 50, and 70 percent of total nitrogen in rations 1, 2, and 3, respectively.
(*b*) Cobalt plus iodine (20 oz. of cobalt sulfate and 6 oz. potassium iodide per ton of salt).
(*c*) 10,000 I.U. of vitamin A and 1,250 I.U. of vitamin D per gram of concentrate.

RESULTS AND DISCUSSION

The effect of the various rations on feed consumption, average daily gain in body weight, and the amount of feed required per pound of gain are shown in Table 2. The growth rate of all groups of heifers was somewhat improved compared with the initial study[3] even though the heifers were about the same size and ate about the same amount of total feed.

[3]Lassiter, C.A. et al. Op. cit.

TABLE 2—Effect of high level urea feeding on the average feed consumption, feed efficiency, and body weight gains of growing dairy heifers

Group	Feed	Daily feed	Initial weight	Final weight	Daily gain	Feed per lb. gain
(No.)		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1	Corn cobs, supplement	12.1 3.9	609	777	1.40	11.4
2	Corn cobs, supplement	12.6 4.0	604	765	1.34	12.4
3	Corn cobs, supplement	11.8 4.0	608	730	1.02	15.5
L.S.D.—1%				—	0.49	2.7
L.S.D.—5%		n.s.	n.s.	—	0.36	2.0

It seems that the addition of sulfur to Rations 2 and 3 improved the growth rate of the heifers. Heifers fed Ration 2, in which urea supplied 50 percent of the total nitrogen, gained about as much as those fed Ration 1, in which urea supplied 30 percent of the total nitrogen.

Sulfur supplementation also appeared to improve the performance of Ration 3, in which urea supplied 70 percent of the total nitrogen. However, the growth rate of the heifers was still significantly less than the heifers fed Ration 1. The difference between the growth rate of heifers fed Rations 2 and 3 was approaching significance at the 5 percent level of probability.

The average daily gains of heifers fed the same grain rations, without sulfur supplementation, were 1.15, .85, and .64 pounds per day for Rations 1, 2, and 3, respectively[4].

No significant difference existed among rations in respect to feed consumption. Heifers fed Rations 1 and 2 had significantly higher feed efficiency than the heifers fed Ration 3.

The appetite and general health of all groups of heifers in this study were excellent. The results showed that heifers fed grain rations in which urea supplies 50 percent of the total nitrogen will make gains comparable to those of heifers fed grain rations in which urea supplies 30 percent of the total nitrogen, provided the ration is adequate in sulfur. When urea supplied up to 70 percent of the total nitrogen in a ration, there seemed to be other factors necessary for proper utilization. Results showed that sulfur is necessary for efficient utilization of urea under the conditions of this experiment.

The over-all performance of heifers in this trial was improved over the first trial. Heifers fed Rations 2 and 3 made about 58 percent better gains in this experiment compared with the first experiment, while heifers fed Ration 1 only made about 28 percent better gains. This difference is probably due to the sulfur supplementation of Rations 2 and 3. However, this would not account for the better performance of heifers fed Ration 1 in this study compared with the first trial.

[4]Lassiter, C.A. et al. Op. cit.

SUMMARY

Twenty-four Holstein heifers were divided into three groups and fed grain rations in which urea supplied 30, 50, and 70 percent of the total nitrogen for a 120-day feeding trial. Enough sulfur was added to the 50 and 70 percent urea rations to make all rations comparable in sulfur content.

The average daily gain of heifers fed the three rations was 1.40, 1.34 and 1.02 lb. for Rations 1, 2, and 3, respectively. The difference in average daily gain between Rations 1 and 3 was significant and the difference between Rations 2 and 3 approached significance. Little difference existed among rations in respect to consumption, but heifers fed Rations 1 and 2 made more efficient gains than heifers fed Ration 3.

Results of this study indicate that sulfur improved the utilization of rations containing high amounts of urea, but that other factors seem to be needed for proper utilization of grain rations in which urea supplies up to 70 percent of the total nitrogen.

THE EFFECT OF CHEMICAL STRUCTURE OF BENZIMIDAZOLES AND RELATED COMPOUNDS ON THE GROWTH INHIBITION OF PLANTS[1]

By THEODORE L. REBSTOCK, CHARLES L. HAMNER, and HAROLD M. SELL

DEPARTMENTS OF AGRICULTURAL CHEMISTRY AND HORTICULTURE

PREVIOUS STUDIES (Rebstock et al., 1955, 1957) have demonstrated that several acid analogs of 2-thiobenzimidazole markedly inhibited the growth of Cranberry bean plants and root development of cucumber seedlings. The acid side chain, the nature of the substituent groups in the aromatic nucleus of the benzimidazole compound, and the position of these groups strongly influenced the inhibitory response of the test plants to these chemicals. This study was continued to determine the effect of alterations in the ring structure of the compound on the growth of Cranberry bean plants and root development of cucumber seedlings.

Several derivatives of benzothiazole have growth-regulating activity. Kraus and Mitchell (1947) observed that (2-benzothiazolylthio) acetic acid was extremely toxic to plants. This same compound has slight activity in delaying abscission of several varieties of apples (Edgerton and Hoffman, 1953).

Beta-(2-benzothiazolylthio) propionic acid at a concentration of 0.001 to 5.0 percent can initiate and stimulate rooting, reduce the number of set fruits in heavy bearing fruit trees, produce higher fruit-set on light bearing trees, and if used in excess may kill plants (Steward, 1951).

(2-Benzothiazolyloxy) acetic acid stimulated cell division in tissue explants from the secondary phloem of carrot roots (Steward and Shantz, 1956) and it was tested as a growth-regulator on the development of Corinth grapes (Weaver, 1954).

[1]Supported by the Horace H. Rackham research endowment of Michigan State University.

ARTICLE 40-82

2-Mercaptobenzoxazole in combination with a carrier has herbicidal action on broad leafed plants without substantially harming narrow leafed plants (Schlesinger and Kosmin, 1953).

MATERIALS AND METHODS

The following compounds were synthesized by procedures reported in the literature: (2-benzimidazolylthio) acetic (Everett, 1931); (2-benzothiazolylthio) acetic (Duffin and Kendall, 1951); β-(2-benzothiazolylthio) propionic (Jansen and Mathes, 1950); (8-purinylthio)-acetic (Albert and Brown, 1954); β-(2-benzimidazole) propionic (Chatterjee, 1929); isothioureidoacetic (Desai et al., 1935); and β-isothioureidopropionic acids (Gresham et al., 1948). The (2-benzoxazolylthio) acetic and (4-oxy-2-pyrimidinylthio) acetic acids were not reported in the literature and were synthesized and characterized in this laboratory.

(2-Benzoxazolylthio) Acetic Acid

Three and two-hundredth gm. (0.02 M) of 2-benzoxazolethiol was dissolved in 40 ml. of anhydrous acetone along with 2.8 gm. of potassium carbonate and 3.0 gm. of sodium iodide. Following the addition of 3.0 gm. of ethyl chloroacetate, the mixture was refluxed 8 hours. After cooling and filtering, the acetone was removed from the filtrate by evaporation. Fifty ml. of distilled water and 3.5 ml. of 6 N sodium hydroxide were added and the mixture refluxed until a clear solution was obtained (30 min.).

After cooling and filtering, the solution was made acid to Congo red indicator paper with 6 N hydrochloric acid. The precipitate was collected on a filter and recrystallized from aqueous methanol until the melting point was constant. The yield was 2.3 gm. of crystals melting at 162-163° C.

Anal. Calcd. for $C_9H_7O_3NS$: C, 51.66; H, 3.37; N, 6.70. Found: C, 51.54; H, 3.59; N, 6.57.

(4-Oxy-2-pyrimidinylthio) Acetic Acid

One and three-tenth gm. of thiouracil were dissolved in 20 ml. of 2 N sodium hydroxide to which was added 1 gm. of monochloroacetic acid dissolved in 10 ml. of distilled water. The solution was gently refluxed for 1 hour, then cooled and filtered. The filtrate was made acid to Congo red indicator paper with 6 N hydrochloric acid and

the mixture cooled in the refrigerator. The precipitate was collected on a filter and recrystallized from boiling water. The yield of recrystallized product which melted at 168-169° C. was 1.3 gm.

Anal. Calcd. for $C_8H_6O_3N_2S$: C, 38.70; H, 3.24; N, 15.04. Found: C, 38.83; H, 3.28; N, 15.17.

Biological Assay

Two methods of biological assay were used for the evaluation of the inhibitory effects of the compounds upon the growth of plants.

One of the methods of assay was the bean leaf test. Seeds of the bean plant *(Phaseolus vulgaris)*, Cranberry variety, were selected for uniformity of size and planted in 4-inch pots in the greenhouse. After germination, all but the uniform seedlings were removed from each pot.

Six to 8 days after planting, when the primary leaves were expanding, the plants were treated with an 0.005 M solution of the test chemical by dipping the primary leaves into the test solution. Visual observations were made as to the relative amount of inhibition of new leaf and stem growth induced by each of the compounds compared with control plants after an interval of 6 days.

The solutions of the chemicals were prepared by suspending enough of the compound in distilled water to give an 0.005 M solution. A definite volume of a saturated solution of sodium bicarbonate was added and the mixture stirred until solution was complete. The pH of the solution was then adjusted to 7.0-7.1 by the dropwise addition of an aqueous 25 percent acetic acid solution; then the volume was adjusted with distilled water.

A solution of sodium bicarbonate neutralized with dilute acetic acid to pH 7 was used for the control plants.

Root inhibition of Marketer cucumber seeds was employed as an additional method of biological assay. Seeds were germinated on a filter paper impregnated with either an 0.005 or 0.0005 M solution of the test compound in a Petri dish at room temperature (about 25° C.) under laboratory conditions of alternating light and darkness.

After 6 days, the longest root was measured and the length of this radical was used as an index of growth inhibition of the test compound compared with control seedlings treated with a neutral solution of sodium bicarbonate and acetic acid.

RESULTS AND DISCUSSION

The results of the bean leaf test are summarized in Table 1. None of the compounds caused as severe an inhibition of the growth of the leaves and stems of the bean plants as did (2-benzimidazolylthio) acetic acid. However, alterations in the ring system did markedly influence the inhibitory activity of these compounds.

The substitution of an oxygen atom for one of the nitrogen atoms of benzimidazole (benzoxazole) resulted in a compound that did not noticeably affect the growth of the plants. Compounds containing a sulfur atom in place of one of the nitrogen atoms (benzothiazole) slightly inhibited the growth of the plants.

TABLE 1—Relative inhibition of the growth of cranberry bean plants 6 days after treatment with test chemicals

Compound	Conc. molar	Relative inhibition(*a*)	Chlorosis
(2-Benzimidazolylthio)acetic acid	0.005	+++	None
(2-Benzoxazolylthio)acetic acid	0.005	0	None
(2-Benzothiazolylthio)acetic acid	0.005	+	Slight
β-(2-Benzothiazolylthio)propionic acid	0.005	+	Slight
(8-Purinylthio)acetic acid	0.005	0	None
(4-Oxy-2-pyrimidinylthio)acetic acid	0.005	0	None
β-(2-Benzimidazole)propionic acid	0.005	+	Slight
Isothioureidoacetic acid	0.005	0	None
β-Isothioureidopropionic acid	0.005	0	None
Imidazole	0.015	+	Slight
Control	.....	0	None

(*a*) The number of plus signs indicate the relative magnitude of inhibition of new leaf and stem growth as compared to control plants.

If the ring system was either a purine or a pyrimidine derivative, the chemical was inactive. Likewise, the open ring compounds, isothioureidoacetic and β-isothioureidopropionic acids caused no visible effect on the plants. When the acid side chain was connected to the benzimidazole nucleus through a methylene group [β-(2-benzimidazole) propionic acid] rather than a thioether linkage, a portion of the inhibitory activity was retained. Unsubstituted imidazole was only slightly inhibitory.

The results of the cucumber root assay are shown in Table 2. The influence of two different concentrations, namely, 0.005 and 0.0005 M are given as the percentage of the root length of the controls.

TABLE 2—Relative root length of cucumber seedlings 6 days after treatment of the seeds(a)

Compound	Concentration	
	0.005 *M*	0.0005 *M*
(2-Benzimidazolylthio)acetic acid	74	69
(2-Benzoxazolylthio)acetic acid	64	71
(2-Benzothiazolylthio)acetic acid	46	76
β-(2-Benzothiazolylthio)propionic acid	28	98
(8-Purinylthio)acetic acid	151	89
(4-Oxy-2-pyrimidinylthio)acetic acid	85	93
β-(2-Benzimidazole)propionic acid	77	130
Isothioureidoacetic acid	74	89
β-Isothioureidopropionic acid	72	99
Imidazole(b)	7	76
Control	100	100

(a) Results are expressed as the percentage of the root length of controls.
(b) The concentrations of this compound were 0.015 and 0.0015 *M*.

At a concentration of 0.005 M all of the compounds inhibited the development of cucumber roots with the exception of (8-purinylthio) acetic acid which appeared to stimulate root formation. The benzothiazole derivatives caused the greatest inhibition of growth at this concentration. Unsubstituted imidazole at an 0.015 M concentration almost completely prevented the formation of roots of cucumber seeds. In most instances, after treatment, the root radical was almost completely devoid of root hairs.

The longest root radical, which developed after treatment with a tenfold dilution of the test compound, was practically in every case as long as the controls. However, several of the treatments markedly altered the appearance of the roots when compared to the controls.

The roots of those seeds treated with (2-benzimidazolylthio) acetic, (2-benzoxazolylthio) acetic, and β-(2-benzimidazole) propionic acids appeared as a single long radical having only a few root hairs. Numerous long root radicals were evident on those cucumber seeds treated with (8-purinylthio) acetic and (4-oxy-2-pyrimidinylthio) acetic acids.

SUMMARY

A study was made of the effect of benzimidazole and related compounds on the growth inhibition of Cranberry bean plants and root development of cucumber seedlings. (2-Benzimidazolylthio) acetic, (2-benzothiazolylthio) acetic, β-(2-benzothiazolylthio) propionic, (2-

benzoxazolylthio) acetic, (8-purinylthio) acetic, (4-oxy-2-pyrimidinylthio) acetic, β-(2-benzimidazole) propionic, isothioureidoacetic, and β-isothioureidopropionic acids were synthesized and tested.

The benzimidazole and benzothiazole derivatives caused the greatest inhibition of growth; while other heterocyclic and open chain compounds only slightly inhibited the growth of the test plants.

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FOLIAR AND SOIL APPLICATIONS OF CHEMICALS FOR THE CONTROL OF PINK ROT OF CELERY[1]

By H. SPENCER POTTER, C. KENNETH CLONINGER, and ALBERT DROST[2]

PINK ROT, a fungus disease on celery caused by *Sclerotinia sclerotiorum* (Lib) DbY., seriously damaged the Michigan celery crop in 1956. Some fields were heavily infested with the disease and were never harvested. The disease varies in its economic importance depending on weather conditions during the growing season. Pink Rot is usually most damaging in a year when the weather is cool and humid with abundant rainfall.

Pink Rot occurs on celery both in the seedbed and in the field. All above ground parts of celery plants are attacked, but the tissue nearest the soil line is usually affected first. The symptoms consist of watersoaked lesions, which are pinkish red in color. Infected tissue breaks down rapidly and eventually becomes slimy and rotten.

White mats of the fungus containing sclerotia usually cover the infected tissue and the soil around the base of the plant. The sclerotia are black, hard, irregularly-shaped structures ranging in size from that of a small seed to ½ inch or more in diameter.

The Pink Rot organism overwinters in the soil or on celery debris both as mycelia and as sclerotia. When temperature and moisture conditions are right, sclerotia become soft and form one to several tube-like fruiting structures (apothecia) from which spores are released (Fig. 1.). Infection may result from invasion by overwintering mycelium or from germination of spores splashed or blown onto the plants.

[1]The authors wish to acknowledge the assistance and cooperation given by Donald Hearl, agricultural agent, Muskegon County; the Workman and Fisher Brothers, celery growers. Helpful suggestions in preparation of the manuscript were offered by Drs. Donald deZeeuw and Richard Kiesling.

[2]Extension specialist in plant pathology; market development pesticide representative, Industrial Chemical Division, Olin Mathieson Chemical Corp.; and secretary, Michigan Celery Promotion Association, respectively.

ARTICLE 40-83

Fig. 1. Dormant and germinating sclerotia of Sclerotinia sclerotiorum (Lib.) Dby., the fungus causing Pink Rot of celery.

The extreme resistance of the sclerotial stage of the Pink Rot organism makes control of the disease by rotation or agronomic practices very difficult. In Florida, where Pink Rot is a serious problem on celery, flooding has produced some satisfactory results. Calcium cyanamid, applied to the soil at very high rates, has also produced a degree of control.[3]

Neither of these measures, however, is feasible in many important celery producing areas. To be effective, flooding must be done when the weather is hot. This is not economical in Michigan muck areas since acreages are limited. Further, continued high applications of calcium cyanamid could create salt accumulation problems in some soils.

The purpose of this study was to determine whether certain selected organic fungicides would effectively control Pink Rot in celery when applied either to the soil or to the foliage.

[3]University of Florida (1956). Commercial vegetable pest control guide. Agr. Ext. Serv. Circ. 152, 42 pp.

MATERIALS AND METHODS

Two separated fields near Muskegon, Michigan, which had an established record of severe celery Pink Rot losses, were selected for this study. The soil in both fields was Houghton muck (reed sedge type).

Plots were measured and permanently staked in order to retain their identity throughout the study. Each plot was 30 feet long and 16 feet wide. Six rows of celery, spaced about 32 inches apart were planted. There was only enough space available at each location for three replications per treatment. Treatments were randomized.

Fungicides tested for their ability to control Pink Rot included: Pentachloronitrobenzene (Terraclor), Sodium methyl dithiocarbamate (Vapam), N-(trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide (captan), and a new compound, N-trichloromethylthiophthalimide (Phaltan). Methods and rates of application for different treatments used in this study are given in Table 1.

TABLE 1—Treatments used in tests to control Pink Rot of celery caused by Sclerotinia sclerotiorum (Lib.) DbY

Treatments	Formulation and rate of application
Terraclor—spray	75% WP, 20 lb./150 gal./A. (two applications)
Terraclor—dust	20% dust, 75 lb./A. (two applications)
Terraclor—broadcast	20% dust, 980 lb./A. (one application)
Terraclor—band	20% dust, 980 lb./A. (one application)
Terraclor+Vapam—broadcast	20% dust, 980 lb.+31% liquid 109 gal./A.
Terraclor+captan—broadcast	20% dust, 980 lb.+50% WP 200 lb./A.
Vapam (high)—broadcast	31% liquid, 109 gal./A.
Vapam (low)—broadcast	31% liquid, 54½ gal./A.
Phaltan (high)—broadcast	50% WP, 120 lb./A.
Phaltan (low)—broadcast	50% WP, 60 lb./A.
Captan—broadcast	50% WP, 200 lb./A.
Check (control)	no treatment

The chemical soil applications were made June 18 and 19, 1957. The Terraclor and captan soil treatments were broadcast uniformly over the plots by hand. Then these plots were disked thoroughly to a depth of 4 inches to insure adequate chemical-soil mix.

Vapam and Phaltan were diluted in water to a concentration equivalent to 1,000 gallons per acre and applied evenly to the soil surface with a common garden sprinkling can. Overhead irrigation was used

to apply ½ inch of water as a soil surface seal to prevent the loss of the anti-fungal active gases from the Vapam-treated plots.

Utah 16 variety of celery was transplanted into the test plots approximately 2 weeks following the soil treatments. The first Terraclor foliage dust and spray applications were made 7 days after transplanting. The final foliar applications were made immediately following the last cultivation, or about 3 weeks before harvest.

The two center celery rows of each plot were harvested, and plants were evaluated individually for the presence or absence of Pink Rot. Those obviously infected with aster yellows were discarded. An average of 150 plants per plot was examined.

RESULTS AND DISCUSSIONS

Disease control data are presented in Table 2. In these tests Terraclor alone or in combination with Vapam or captan provided good control of Pink Rot. Vapam, at the highest rate of application, also proved beneficial. None of the other treatments, however, was significantly better than the control.

Foliar application of Terraclor in one experiment resulted in distinctly less infection than did any of the soil treatments (Fig. 2). Dusts and sprays were equally effective in controlling Pink Rot. Sprays, however, produced some injury on the foliage of the young transplants.

TABLE 2—Effect of soil and foliar chemical applications in the control of Pink Rot of celery caused by Sclerotinia sclerotiorum (Lib.) DbY

Treatment	Percent of plants diseased	
	Field 1	Field 2
Terraclor—spray	5**	2**
Terraclor—dust	8**	7**
Terraclor—broadcast	29**	9**
Terraclor—band	31**	8**
Terraclor+Vapam—broadcast	29**	5**
Terraclor+captan—broadcast	..	10**
Vapam (high)—broadcast	38*	11**
Vapam (low)—broadcast	59	34
Phaltan (high)—broadcast	49	37
Phaltan (low)—broadcast	59	39
Captan—broadcast	48	..
Check	59	40
*LSD 0.05	16	7
**LSD 0.01	21	9

Fig. 2. Pink Rot control on celery resulting from foliar dusting with Terraclor. (Note the rot at the base of the celery stalks not dusted with Terraclor.)

Laboratory tests indicated that dormant sclerotia are not affected by any of the chemical treatments used in these field studies. Therefore, it is believed that effective control of the Pink Rot organism by soil treatment is possible only when sclerotia are germinating.

Terraclor is a very stable chemical which will retain its effectiveness for long periods compared to a volatile material such as Vapam. This fact may help to explain the trend toward better control with combinations of Terraclor and Vapam than with Vapam alone.

The better control obtained by Terraclor foilage applications may have been due to the chemical protection afforded the plant tissue in addition to the eradicating effect on the organism in the soil. The soil treatments with Terraclor were apparently effective against germinating sclerotia in the upper 4 inches of soil only. Subsequent cultivations undoubtedly resulted in turning up the deeper-buried, dormant sclerotia which then germinated.

In the case of plants without foilage protection, the spores released could infect the plant tissue and cause the disease. Coating plant tissues with fungicides also offers protection against wind borne inoculum from distant sources of infection.

Deep plowing appears to be helpful in controlling Pink Rot. A celery field near Muskegon, Michigan, in which Pink Rot had resulted in a complete loss of the crop in 1956, was plowed to a depth of 10 inches and replanted to celery the following year. A minimum of infection occurred in this field whereas in an adjacent field plowed to a normal depth, the incidence of Pink Rot was high. It is possible that deep plowing combined with chemical spray or dust applications may eventually offer the best opportunity for minimizing Pink Rot damage to Michigan celery.

SUMMARY

When the growing season is cool and wet, the Michigan celery crop is very often seriously affected by Pink Rot, a fungus disease caused by *Sclerotinia sclerotiorum* (Lib.) DbY. In this study, 11 chemical treatments were evaluated for their effectiveness in preventing the disease. Two of these treatments were foliar applications and the remainder were applied to the soil before planting. Dust and spray applications of Terraclor appeared to give the best control of Pink Rot. Soil treatments of Terraclor alone and in combination with Vapam and captan were also effective, as was Vapam at the higher concentration tested.

LOCATION AND SITE SELECTION FACTORS FOR WINTER SPORTS AREAS IN MICHIGAN

By CLARE A. GUNN

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With an annual expansion of over 30 percent[1], the winter sports business of Michigan holds promise of upsetting the state tradition of being a vacation land in summer only.[2] Although summer remains the major season, several operators of resort business places are enjoying a much-extended season. Increased popularity of the off-seasons (spring, fall, and winter) may make investments in new facilities in the right locations much more feasible than they have been in the past.

Accompanying this unprecedented growth of the winter sports business has been a general lack of available information on the planning of new areas. The trial and error method has been the rule. Some guidance from outside Michigan has been misleading. Many mistakes in location, site selection, and development have resulted.

This study was carried on to determine the desirable location and site factors for winter sports businesses in Michigan. It is based upon inspection of 23 existing areas in both peninsulas of Michigan; interviews with as many operators of businesses; counsel with nationwide specialists in skiing, climatology, and winter sports; and review of literature.

MARKET AND ACCESS

In contrast to the distribution of manufactured products to the consumer, winter sports businesses depend upon the customers coming to the areas. Therefore, the number of persons interested in winter

[1]From the Ross Roy Advertising Agency, Detroit; retained by the Michigan Tourist Council for nationwide advertising of the state.

[2]Clement, Harry (1957). Your community can profit from the tourist business. U.S. Department of Commerce, U.S. Government Printing Office, Washington. 25 pp.

ARTICLE 40-84

sports, their ability to pay for services, and the means of transporting them to the areas become important when considering the location of new businesses.

While no precise prediction of future popularity can be made, present trends indicate that young people dominate the winter sports market.[3] The majority of participants are from 15 to 34 years of age. Other important age groups are teen-age children and winter-vacationing families, including pre-school children and adults over 40. From the potential market standpoint, the future of the winter sports business looks bright considering that those in the 15 to 34 age group in the U. S. may number 61 million by 1970, compared to 46 million today.

Logically, the younger age groups are not able to spend as much as those who are older and have higher incomes. However, the high patronage in the younger age group indicates a willingness to pay for transportation and basic tow fees. The popularity of more complete meal service, high quality rooms, and extra services seems to parallel increases in incomes.

The automobile is the dominant means of transportation.[4] Therefore, in selecting a new location, the operator must consider highway routes, highway quality, and highway upkeep in winter. The primary market for winter sports patronage in Michigan lies in the metropolitan-industrial belt from northern Illinois to northern Ohio. The small number who come by bus (less than 4 percent[5]) also emphasizes the importance of good highway access.

Ski trains, popular in eastern states, do not appear to be popular in the lower peninsula but do contribute to business in the upper peninsula.[6] Air travel to winter sports areas is complicated by ground travel at each terminal, the handling of cumbersome equipment, and adverse flying conditions.

COMMUNITY SERVICES

So far, only a small number of resorts provide entertainment, complete food service, and lodging at the winter sports area. The majority are highly dependent upon the nearby community for these services.

[3]Luck, David J., and Clare A. Gunn (1954). Winter resorts in Michigan. Res. Rep. No. 11, Bur. of Bus. Res., Mich. State Univ. 59 pp. Also Drake, Louis (1955). Skiing in the upper peninsula of Michigan, Mich. College of Mining & Technology, Houghton. 31 pp.
[4]Luck, David J. and Clare A. Gunn (1954). Op. Cit.
[5]Luck, David J. and Clare A. Gunn (1954). Op. Cit.
[6]Drake, Louis (1955). Op. Cit.

Therefore, in selecting a location it becomes important to survey the number and quality of establishments providing entertainment, beverages, food service, and lodging. These services are important to skiers and other winter sports enthusiasts.

In addition to the commercial services, those provided by agencies and organizations should be reviewed. A more favorable location

Fig. 1. The increase in snowfall from south to north is not uniform due to the influence of Lakes Michigan and Superior on the North American cold air waves sweeping down from the northwest. Within this dominant trend, however, significant differences in snowfall distribution can occur each season because changes in the force and direction of winds produce alternating continental and semimarine types of climate. (Map data from U. S. Weather Bureau, East Lansing Office.)

is one near a community with good street upkeep; high standards of sanitation; active chamber of commerce; active youth organizations; good medical and hospital services; and general community support of winter resorting.

SITE CHARACTERISTICS

Favorable site characteristics are essential to success. Those areas with poor sites bring poor returns on the investments and little or no profits for the owner or manager. The popular concept is that an exceedingly high hill is the prime requisite. Study has revealed many other and equally important factors of site selection.

Adequate Snowfall

Much of Michigan has greater snowfall than any point between the Rocky Mountains and New England.[7] This unique aspect of its climate, largely due to the influence of the surrounding Great Lakes, makes the state very well suited to winter sports.

Reference to Fig. 1 shows that much of Michigan has over 60 inches of snowfall per year. Those areas with lesser annual averages must depend more upon artificially prepared snow. Snow-making equipment is available, but the added costs of installation, operation, and upkeep must be justified by increased volume of business.

Long Winter Season

As important as snowfall is the amount of cold weather to retain the snow. In an attempt to provide information on this factor, Fig. 2 was prepared from data supplied by the U. S. Weather Bureau. It illustrates relative differences in length of winter season. Reference to both Fig. 1 and 2 should assist in evaluating a location regarding the influence of weather.

Suitable Area and Topography

A good winter sports site includes over 80 acres of both hilly and reasonably level land. Skiing and tobogganing require elevation differences of over 100 feet and slopes from 10 to 60 percent or over. Nearly level (but well-drained) land is needed for building sites, parking areas, drives, and skating rinks.

[7]Luck, David J. and Clare A. Gunn (1954). Op. Cit.

In selecting sites for recreation skiing, three categories of skiers need to be considered: beginners, intermediates, and experts. For safety's sake, each category needs a separate slope. At present, the greatest volume of patronage is from those of little or no skiing experience. Hence, the greatest number of slopes should be developed

Fig. 2. The combination of a semimarine and a continental type of climate shortens the winter season on the coastal regions of Michigan as compared to the central regions. When this is correlated with snowfall (Fig. 1) it will be noted that several northern counties have both heavier snowfall and longer winter season, but some areas with relatively heavy snowfall may not be as desirable due to the shorter winter season. Conversely, some areas having an extended season of lower temperatures may be made usable for winter sports with the addition of snow-making equipment.

Fig. 3. While adequate acreage of hilly land is essential for the development of ski slopes, a significantly large amount of flat land is needed for buildings and parking areas. For example, the Boyne Mountain Ski Lodge, shown in this picture, would not have been able to increase its business manyfold if ample acreage of flat land had not been purchased at the start. The buildings and parking areas have been more than tripled in size since the original construction.

for beginning and intermediate skiers. In the future, as more skiers gain in skill, the more difficult slopes will be in greater demand.

By coincidence of its glacial history, Michigan has hilly land in most of the areas of heavier snowfall.[8]

Orientation

The position of the ski slope face with regard to sun and wind exposure can influence its use by as much as 100 percent. It is important to business success to have slopes properly oriented to prevent excessive chilling, wind erosion, and melting from the sun.

Prevailing winter winds in Michigan are from the northwest and west. Therefore, a high percentage of snow blows away when the topography is such that severe exposure to these winds exists. High ridges to the west or northwest of the areas to be developed tend to deposit more snow by slowing the velocity of snowladen winds.

[8] U. S. Geological Survey topographic maps of many areas of Michigan are available from the Geological Survey Division of the Michigan Conservation Department, Lansing.

Ideally, ski slopes or toboggan runs should face to the north or northeast to avoid damaging effects of the sun. Some successful runs have been made in an easterly direction, but only when other factors, such as width of cleared area and height of forest cover, were extremely favorable.

Forest Cover

Cleared land is less desirable than forested land. Tall forests are superior to low forest cover. This is related to the damaging effects of both wind and sun. With adequate forest production, a slope actually receives more snow as well as retaining it for a longer period of time.

Suitable Soil

Land which is rocky or filled with springs may make development difficult or impossible. Soil conditions should support a good grass turf on ski slopes; have adequate drainage for good drive and parking area construction; and be suited to good building construction.

OTHER FACTORS

When selecting a location for any winter sports business, it is essential to investigate sources of water. Water will be needed for the many services at the central shelter, such as the snack bar and rest rooms. If snow-making equipment is contemplated, quantities of water in excess of 80 gallons-per-minute may be needed.

Electrical power supply should be available. Minimum light and water pump service can be supplied by a generator on the site, but the business will be limited severely without "high-line" power.

Telephone service to the site is essential. Communication with the nearby community and its many business places is needed. Safety dictates communication with medical and hospital services. Reservations and other aspects of the operation of the business are carried on much more efficiently by telephone.

Professional guidance is helpful in selecting locations. Expert help on topography, soils, forests, climatology, and deep rock geology can save thousands of dollars for the investor in winter sports facilities. Professional assistance from landscape architects, architects, and engineers may avoid poor site selection and development.

EFFECT OF SPICES IN FEED ON POULTRY MEAT FLAVOR

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DO YOU LIKE your poultry seasoned? Most people do. That is why housewives stuff birds with highly spiced dressings and baste with butter and condiments.

Can poultry meat be seasoned indirectly by feeding spices to the chickens themselves? This was explored in the experiments to be described.

Normal chicken flavor develops from the meat, rather than the fat, of poultry flesh, and according to Bouthilet (1951) has characteristics resembling glutathione.

Different feedstuffs affect the flavor of poultry according to a number of researchers. Maw (1935) stated that birds fed corn were superior in flavor to those fed barley and wheat. Schaible et al. (1938) found that fish oil, formerly used unconcentrated in feeds as a vitamin supplement, was responsible for the "fishy" flavor of certain turkeys. Titus (1955) reported that corn oil and peanut oil gave very satisfactory flavor to the flesh of broilers.

In the present study, certain spices and a flavor enhancer were incorporated in the feed to find out if they can flavor poultry meat and, if so, how acceptable the resulting products would be.

PROCEDURE

Three feeding experiments were conducted in which White Plymouth Rock male broilers, 8 weeks old, were placed in finishing batteries, five to a compartment, and fed a regular broiler mash prior to feeding the experimental rations. Garlic, celery seed, allspice, sage, cloves, as well as the flavor enhancer, monosodium glutamate (MSG) were used in the feeds as described. After completion of the

ARTICLE 40-85

experiments, the birds were slaughtered and carefully eviscerated. They were then baked at 350° F. for 1½ hours.

Two taste panels were formed to reduce the number of samples tasted per person and, thus, prevent taste-bud fatigue. The members of the panels were not previously trained and evaluated flavor only. They had no information regarding the treatments of the birds tested. Panels consisting of 22 or 27 participants tasted the skinless flesh and scored the samples on a hedonic scale numbering 1 to 7 as follows: 1. Dislike extremely 2. Dislike very much 3. Dislike slightly 4. Neither like nor dislike 5. Like slightly 6. Like very much 7. Like extremely The scores were analyzed by Duncan's (1955) Multiple Range Test.

Experiment I

Dehydrated garlic powder (1 pound equivalent to 6 pounds of fresh garlic), celery seed, allspice, sage, clove, and MSG were added to a basal ration (Table 1) at the rate of 1 pound of spice to 5 pounds

TABLE 1—Composition of basal rations used

Ingredient	Experiments	
	I	II and III
	lb.	lb.
Corn, ground	...	900
Barley, ground	400	...
Oats, ground heavy	450	300
Wheat, ground	400	200
Wheat bran	...	100
Alfalfa meal, 17% protein	...	100
Meat and bone scraps, 50% protein	100	50
Soybean oil meal	400	300
Fish meal	100	25
Whey, dried	50	25
Yeast, dried	50	...
Limestone, ground	30	25
Bone meal, steamed	20	30
Salt (iodized)	6	5
Vitamin A and D feed. oil, 2250A 300D	5	3
Pre-pen 2:3 (Merck)	...	2
Manganese sulfate, feed-grade	.4	.26
Choline chloride, 25% dry mix	3	...
Myvamix, Vit. E feed suppl.	.5	...
Riboflavin	5 gm.	...
Niacin	20 gm.	...
Calcium pantothenate	2 gm.	4 gm.
Totals	2015+	2065+

TABLE 2—Feed intake as affected by spice additions

Spice used	Feed consumed per bird in 4 days
	lb.
None	.91
Celery seed	.78
Allspice	.72
MSG	.63
Garlic	.57
Sage	.51
Clove	.31

of feed. The experimental rations were fed for 4 days and removed 1 day before processing the birds.

Spices were purposely fed at high levels for a short period of time because it was thought that it might be more economical and effective than if fed at low levels for a longer time.

Results—The presence of the high concentration of spices reduced the consumption of feed compared to the control ration as shown in Table 2. According to Kare (1957), chickens have a sense of taste and this may explain the lower feed intake with the spices.

The garlic-fed birds received the lowest average hedonic rating (Table 3). It was evident that garlic had been absorbed into the flesh of the birds because it was identified by 4 of 22 members of Panel A (Table 6).

TABLE 3—Relationship between feed additives and meat flavor in Experiment I

Average hedonic flavor scores for Experiment I			
Panel A (22 judgments)		Panel B (27 judgments)	
Spice	Av. scores	Spice	Av. scores
None	5.4	None	4.5
Celery	4.8	MSG	4.8
Clove	4.7	Sage	4.4
Garlic	3.5**	Allspice	4.1*

**Difference from control, celery, and clove is significant at 1 percent level.

*Difference from MSG is significant at 5 percent level.

The other spices were not identified in the cooked samples. Panel B gave birds fed allspice the lowest score—significantly lower than that given birds on the MSG, but not for the control ration. However, this average score meant only that it was neither liked nor disliked. Birds fed MSG were rated higher in flavor than any other birds, although the difference between MSG and the control birds was not significant. The control birds were scored high, especially by Panel A and in these, no adverse flavors were reported.

Although the panels did not taste chicken livers, it was noted they had a pronounced garlic flavor. This is further evidence that the garlic had been absorbed and entered the circulatory system. The garlic flavor of the liver appeared much stronger than that of the muscle meat.

Experiments II and III

The levels of spices in the next two experiments were reduced and the rations fed for a longer time. For 8 days, 3 ounces of spice were added to 10 pounds of feed. During the next 5 days, 5 ounces were added to 10 pounds, except for garlic which was added to 12 pounds of feed. Spices used were garlic, clove, MSG, and sage. The birds were male, White Rock broilers, 8 weeks old, as in the previous trial.

Experiment III was the same as Experiment II, except that 2.2 grams of dienestrol diacetate was added to each ration. This compound with estrogenic activity was incorporated to find out if a greater and more uniform fat deposition in the flesh might result in improved spice distribution.

The garlic powder used in these two experiments was not dehydrated as in the first experiment; it was a milder product packed for hotel and restaurant use.

TABLE 4—Pounds of feed consumed per bird during the 8th and 9th weeks

Spice	Experiment II	Experiment III
None	3.0	3.0
Garlic	2.8	2.8
Clove	2.8	2.8
MSG	2.6	2.9
Sage	2.6	2.6

TABLE 5—Average hedonic flavor scores from Experiments II and III

Experiment II (22 judgments)		Experiment III (22 judgments)	
Spice	Scores	Spice	Scores
None	4.5	None	4.6
MSG	4.7	MSG	5.0
Clove	5.0	Clove	4.1(*b*)
Sage	4.8	Sage	4.6
Garlic	3.9(*a*)	Garlic	4.4

(*a*) Difference from clove is significant at 1 percent level; from sage and MSG, at 5 percent level.
(*b*) Difference from MSG is significant at 1 percent level.

Results—With spices fed at a reduced level for a longer time, feed consumption improved but it was still less than for the control groups (Table 4).

In Experiment II, chickens fed garlic again received the lowest hedonic rating, but were not significantly different from the control birds (Table 5). Five panel members identified garlic flavor in the meat and 3 disliked it extremely (score 1). Birds fed cloves, sage, and MSG, received a significantly higher score when compared to

TABLE 6—Hedonic scores for Experiments I, II, and III

		Experiment I								Experiment II					Experiment III				
		Panel A				Panel B													
	Hedonic scale	Control	Celery	Garlic	Clove	Control	MSG	Sage	Allspice	Control	Garlic	Clove	MSG	Sage	Control	Garlic	Clove	MSG	Sage
Like extremely	7	2	3	1	2	1	1	.	.	.	.	2	1	.	.	1	1	.	.
Like very much	6	11	3	3	4	9	8	7	3	6	7	3	3	7	7	6	2	6	5
Like slightly	5	5	8	4	6	4	10	9	9	7	2	11	11	6	8	5	6	10	9
Neither like nor dislike	4	2	4	2	7	5	3	4	8	5	2	5	5	7	3	1	5	6	4
Dislike slightly	3	2	4	4	2	7	5	4	4	2	8	1	1	2	1	7	6	.	3
Dislike very much	2	.	.	4	1	1	.	3	2	2	.	.	1	.	2	2	1	.	1
Dislike extremely	1	.	.	4	.	.	.	.	1	.	3	.	.	.	1	.	1	.	.

garlic-fed birds than the controls. Birds fed sage and MSG were equally as acceptable as the control birds.

In Experiment III only one panelist identified garlic. The higher score, together with only one identification of garlic, indicates that dienestrol diacetate caused a depression of the garlic flavor in the cooked broiler meat. Strong flavors of garlic and cloves, however, were noted in the livers by the authors. Dienestrol diacetate caused reduced comb size in the birds so it was active physiologically.

In contrast to Experiment II, broilers fed cloves had a significantly lower score when compared to MSG, but not to the control. MSG-fed birds again scored higher than the control birds, but the difference was not statistically significant. Birds fed sage and MSG, as well as the controls, had no flavors which were identified.

SUMMARY

Certain spices were added to finishing feeds to find out if they would affect the flavor of broilers after they had been baked. Garlic, cloves, celery seed, allspice and sage, as well as the flavor enhancer, monosodium glutamate, were used, and the feeds were fed to 8-week-old White Rock broilers.

The cooked birds were scored by two taste panels using a hedonic scale for flavor only. Only garlic was identified in the muscle meat after cooking. Garlic-flavored chickens were rated inferior to the control birds. Additions of dienestrol diacetate to the feed appeared to depress the garlic flavor in meat.

Birds fed monosodium glutamate were rated consistently higher than the control, but the difference was not significant. The other spices did not significantly affect taste appeal.

Rations spiced at high levels reduced feed consumption, compared to control rations.

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ACKNOWLEDGMENT

Thanks are due to Dr. H. C. Zindel for suggesting the problem and to Mrs. Sue Walters, College of Home Economics, Michigan State University for assistance in performing taste panel tests.

THE EFFECT OF WASHING EGGS ON HATCHABILITY

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"What should I do with dirty hatching eggs? Shall I market them, wash them and then set them, or set them as they are?" This is the dilemma often faced by the hatcheryman.

For years, if a hatcheryman cleaned hatching eggs at all, he used some dry abrasive such as sandpaper or steel wool. In older literature dealing with the washing of eggs, it was reported that washing increased spoilage by increasing the size of the pores and thereby allowing bacteria to enter.

With the advent of thermostatically controlled egg washers and detergent-sanitizers, the washing of commercial eggs has, in many cases, become more or less routine. What is the effect of these newer washing procedures when applied to hatching eggs? Would these washed eggs hatch? If so, would they hatch as well as clean eggs or unwashed dirty eggs? This study attempts to answer these questions.

EXPERIMENTAL PROCEDURE WITH CHICKEN EGGS

Some 1,618 eggs from Single Comb White Leghorn breeders were divided into five approximately equal groups which were treated as follows:

Group 1.

Washed for 5 minutes in a water solution (2 ounces to 8 gallons of water) of a commercial detergent-sanitizer (Haviland Egg Detergent-Sanitizer, which is a quaternary ammonium compound manufactured by Haviland Products, Grand Rapids, Mich.) in a Keenco Egg Washer, Model 750, at 110°F.

ARTICLE 40-86

Group 2.

Washed for 5 minutes in a water solution (2 ounces to 8 gallons of water) of a special non-foaming detergent-sanitizer (distributed by Chore-Time Equipment, Inc., Milford, Ind.) in an Egg Queen Washer at 110°F.

Group 3.

No treatment. These eggs were dirty (from fecal material, broken eggs, nest litter, etc.) when gathered.

Group 4.

No treatment. These eggs were clean when gathered.

Group 5.

Dry-cleaned with a commercial machine (Egg-O-Matic) which was developed for this purpose.

All eggs were from the same flock of breeding birds. Where possible, eggs were randomized into the five different treatment groups. The eggs were held for 3 days at 60°F. prior to being placed in the incubator. All eggs were incubated simultaneously in the same incubator.

Infertile eggs and eggs containing dead embryos were detected by candling on the eighteenth day of incubation. Both the infertile eggs and the eggs containing dead embryos were broken out and checked, by holding them under an ultra-violet light, for the presence of fluorescent bacteria, which are partially responsible for so-called "sour" eggs.

RESULTS WITH CHICKEN EGGS

The results of the experiment involving the effect on subsequent hatchability of chicken eggs that have been washed, or dry cleaned, are given in Table 1. Both groups of washed eggs hatched better than either the dirty or clean control groups and better than the dry-cleaned group.

When these data were statistically analyzed, the only significant difference in hatchability was between the group of eggs washed in the Egg Queen washer (Group 2) and the clean control (Group 4). This was probably due to a chance sampling rather than being a true

TABLE 1—The effect of different cleaning methods on subsequent hatchability of Single Comb White leghorn eggs

Group	Treatment	No. eggs set	No. infertile eggs	No. fertile eggs	No. chicks	Percent hatch of fertile eggs
1	Washed(*a*).....	322	43	279	241	86.37
2	Washed(*b*).....	321	36	285	248	87.02
3	Control (dirty)...	326	38	288	240	83.33
4	Control (clean)...	322	34	288	222	77.08
5	Dry-cleaned.....	327	40	287	237	82.57

(*a*) In Keenco Egg Washer, Model 750, in water solution of Haviland Egg Detergent-Sanitizer.
(*b*) In Egg Queen Washer in water solution of non-foaming detergent-sanitizer distributed by Chore-Time Equipment, Inc.

significant difference, as a preliminary test prior to the tests herein reported had shown no significant difference between eggs treated in the same manner as Group 2 eggs and clean controls.

No sour eggs were detected from any of the groups.

EXPERIMENTAL PROCEDURE WITH TURKEY EGGS

The turkey hatcheryman often has the same dirty-egg problem faced by the chicken hatcheryman. His alternatives are fewer since there is no commercial food market for turkey eggs.

To determine the effect of washing on subsequent hatchability of turkey eggs, 452 eggs from Broad Breasted Bronze turkey breeders were randomly divided into three approximately equal groups. Since these eggs were laid in trapnests, it was possible to randomize each hen's eggs into the three groups. All of these eggs were relatively clean when gathered, so no naturally dirty control was possible. The three groups were treated as follows:

Group 1.

Washed for 5 minutes in a water solution (2 ounces to 8 gallons of water) of a commercial detergent-sanitizer (Haviland Egg Detergent-Sanitizer, which is a quaternary ammonium compound manufactured by Haviland Products, Grand Rapids, Mich.) in a Keenco Egg Washer, Model 750, at 110°F.

Group 2.

Washed for 5 minutes in a water solution (2 ounces to 8 gallons of water) of a special non-foaming detergent-sanitizer (distributed by

Chore-Time Equipment, Inc., Milford, Ind.) in an Egg Queen Washer at 110°F.

Group 3.

No treatment.

These eggs were from 3- to 17-days old at the time they were placed in the incubator. All eggs were incubated simultaneously in the same incubator. Infertile eggs and eggs containing dead embryos were candled out on the twenty-fifth day of incubation. The candled-out eggs were then broken-out and checked for the presence of bacteria as were the chicken eggs.

RESULTS WITH TURKEY EGGS

Comparisons of hatchability of washed and unwashed turkey eggs are given in Table 2. One group of washed eggs (Group 1) hatched slightly better than the clean controls (Group 3); while the other washed group (Group 2) gave a hatchability figure somewhat below that of the clean control group. Appropriate statistical analyses showed no significant differences between any of the three groups of eggs. Again, no sour eggs were detected.

TABLE 2—The effect of washing on subsequent hatchability of Broad Breasted Bronze turkey eggs

Group	Treatment	No. eggs set	No. infertile eggs	No. fertile eggs	No. poults	Percent hatch of fertile eggs
1	Washed(*a*).....	149	38	111	61	54.95
2	Washed(*b*).....	151	37	114	56	49.12
3	Control (clean)...	152	45	107	57	53.27

(*a*) In Keenco Egg Washer, Model 750, in water solution of Haviland Egg Detergent-Sanitizer.
(*b*) In Egg Queen Washer in water solution of non-foaming detergent-sanitizer distributed by Chore-Time Equipment, Inc.

CONCLUSIONS

1. If done properly, chicken eggs may be either washed or dry-cleaned without impairing their subsequent hatchability.
2. Turkey eggs, also may be washed with no deleterious effects on hatchability if the correct materials and proper procedures are followed.

IMPACT OF THE "COUNTY AGENT" TELEVISION FILM SERIES[1]

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SUMMARY

The aspect of the study reported here focuses upon the answers to two questions: (a) Will the County Agent television film series appeal to a general audience? (b) Will the County Agent television film series have a measurable impact upon that general audience regardless of sex or place of residence, i.e., urban, rural non-farm, and farm?[2]

1. A properly executed television series devoted to an agricultural topic can achieve a measurable impact upon the general audience, farmer and city dweller alike. In the case of the County Agent television film series, both sample programs resulted in significant increases in learning and desired shifts in attitude for groups in all sex and residence categories.

2. The general audience can be interested in the problems of agriculture when they are presented through television. In the case of the County Agent series, the WKAR-TV Program Analyzer data obtained using the "like-dislike" scale suggested the series had sufficient appeal to the general audience to attract such viewers on its own merits.

3. Such a television series can hold the interest of a general audience even though some viewers are more familiar with the topic presented than are others. In the case of the County Agent series, an imaginative and comprehensive treatment of the dangers of

[1]The assistance of Charles H. Proctor, consulting service, department of statistics, Mich. State Univ., is gratefully acknowledged. The substantial nature of this assistance is described in WKAR-TV Research Report 573M.

[2]For a complete report of the experiment, including a detailed discussion of method, see I. R. Merrill, The impact of an educational television series. WKAR-TV Research Report 573M, Mich. State Univ., East Lansing. (In preparation)

ARTICLE 40-87

"quickie" diets and the advantages of minimum soil tillage sustained interest and achieved impact despite variations in the viewers' subject-matter familiarity.

4. For a modest increase in expense, the addition of Cloze Procedure (as a measure of learning) and the Semantic Differential (as a measure of desired shift in attitude) to profile data obtained by means of the WKAR-TV Program Analyzer appears to present more comprehensive information on the interest and impact of an educational television program than does profile analysis alone.

5. It is possible to measure experimentally the impact of a television series for a reasonable fraction of the total series budget. Such findings allow the extension specialist and television producer to evaluate the success of their work. They provide evidence upon which the television station manager can base a decision to carry the series, and upon which the extension service administrator can plan the size of future budgets for presenting information by television.

INTRODUCTION

The presentation of a television film series by the Cooperative Extension Service raises questions for the extension specialist, for the producer, the television station manager, and the extension service administrator.

The specialist can do a program (even a highly successful one) and never see or hear from a single viewer. The producer has the problem of deciding how to translate the knowledge and ability of the specialist in terms of the television medium. The station manager must decide whether to carry this series or one among others competing for time on the air. The extension service administrator must decide whether the relatively high outlay for television is justified.

The production of the County Agent television film series provides an example of the above questions, and the research conducted illustrates an attempt to answer them. The series of 13 programs, each 26 minutes long, was produced on film in color by Robert Worrall and Margaret McKeegan of the Michigan State University Cooperative Extension Service. It was presented over WKAR-TV, the noncommercial educational television station owned and operated by the university, and bicycled to 12 commercial stations.

County Agent was first broadcast in color by WNEM-TV, Saginaw, and thus Michigan State became producer of the first television film

program to be produced and presented in color in Michigan. Cost of the series, excluding research, amounted to $41,600.

The purpose of the series was to impart information and to encourage an attitude of understanding and approval on the part of the general audience, not just farm families. The information concerned new developments and applications in agricultural research, ranging from a program on human nutrition and the danger of "quickie" diets to a program on the advantages of minimum soil tillage.

As for attitudes, it was hoped that viewers would evaluate the research concepts as good, and would regard more favorably the sources of such information; namely, the county agent, agricultural research, and Michigan State University. This latter aim, of shifting attitudes, is difficult to accomplish, and there have been cases where a "boomerang effect" has been achieved instead (Kendall and Wolf, 1949).

It was hoped the series would have a roughly equal impact on both men and women, regardless of their place of residence. In addition, the producers desired some analysis of production techniques to guide them in the preparation of future series.

In the face of these general questions, it became apparent that an experimental study would yield the most results for the amount of research funds, approximately $2,000, available.

Before the experiment was designed, it was agreed that the sample programs of the series would be considered to have a measureable impact upon the viewers involved if learning took place and attitudes were shifted in the desired direction as a result of the presentation of the program.

METHOD

The experiment employed the factorial design, suitable to analysis of variance, and consisted of a general audience of 120 Subjects, all adults, who were selected according to sex and place of residence and placed in groups of 10 similar persons each (Kempthorne, 1952). The 60 men were divided into two groups from urban, two from rural non-farm, and two from farm residences, as defined by the U. S. Bureau of the Census (1952). The 60 women were grouped in the same manner.

The two sample programs chosen to represent the series were selected on the basis of divergent content and assumed difference in

production techniques. The impact of the program on human nutrition and diets was considered more likely than any other program of the series to differ from the program on soil tillage according to both sex and residence factors.

Measurements were planned in relation to impact and general program appeal. As indicated above, impact analysis involved measurements of learning and shifts in attitude. Two measures of learning were selected, Cloze Procedure and the WKAR-TV Program Analyzer (Taylor, 1956, and Merrill, 1956). Cloze Procedure was employed as a measure of learning because a pre-test of this variety offers minimal cues regarding the relative significance of information to be presented. As a result, it was felt that the difference score between the pre- and post-tests represented a measure of total learning reasonably attributable to information presented during the program. The Program Analyzer was used to give a profile of learning as it took place during the presentation itself.

The Cloze Procedure is similar to a sentence completion test in which every nth word of a passage is deleted (Taylor, 1956). The Subject is required to fill the blank with the correct word. In this case, the exact sentences used in the program were selected from passages indicated as important by the producers. The passages were long enough to provide two forms of the test for each sample program.

The WKAR-TV Program Analyzer is an electrical apparatus with 10 stations and a single pen recording meter (Merrill, 1956). By turning a button at the station, the Subject may vary the resistance in the circuit and register his reactions according to a prearranged scale. The Subject views the program and simultaneously records his reactions, and the summated response of all 10 Subjects is reported by pen on a roll of paper moving within the meter.

Attitude shift was measured by the evaluative factor of the semantic differential using the (good-bad) and (nice-awful) scales (Osgood et al., 1957). The Semantic Differential was considered to have the same advantages in attitude measurement that pertained to Cloze Procedure as a measure of learning. Sources (who said it) and concepts (subject matter) were specified for each sample program in advance by the producers according to desired shift.

Considering both scales of the evaluative factor, the number of Subjects within the group of 10 individuals making a shift in attitude regarding a particular concept was examined to determine the direction of shift. Excluding those Subjects who failed to shift, the number

of "more favorable" Subjects was compared with the number of "less favorable" Subjects, using a table of binomial probabilities for small numbers. The criterion employed was the .05 level of statistical significance.

General program appeal was included in the study, because it was considered possible that an audience captive in the laboratory might reflect some minimum extent of impact when an audience free to turn the dial might choose not to view the sample programs at all. Measurement of general appeal was made by means of the WKAR-TV Program Analyzer as the program progressed.

The following general procedure was repeated for each of the 12 groups. The 2-hour session began with pre-tests of Cloze Procedure and the Semantic Differential. The Subjects then viewed one of the sample programs while operating the WKAR-TV Program Analyzer. Six of the 12 groups rated the program according to a "like-dislike" scale, and six according to a "learning-not learning" scale.

Post-tests were then administered for both learning and attitude shift. This concluded the first half of the session. The procedure was then repeated appropriate to the program not viewed previously. Sample program, scale for Program Analyzer ratings, and test sequence were varied systematically among groups. The final portion of the session was then devoted to a group interview.

The equipment involved included 16mm motion picture projector and screen, test materials, stop watch, and the WKAR-TV Program Analyzer.

RESULTS

Impact

Learning. Difference scores between the pre- and post-tests, constructed according to the Cloze Procedure method, were subjected to analysis of variance, with the results shown in Tables 1 and 2. Eight groups, consisting of all men and women from urban and farm places of residence, were included in the analysis. The F-ratios for the grand means indicate that learning achieved by all groups from each sample program was significant far beyond the .01 level. These ratios for the two sample programs were interpreted as highly similar. This similarity will follow.

The F-ratio for "within groups residual" was not significant for either sample program. This indicates that the means of the groups

TABLE 1—Variance in Cloze Procedure difference scores after viewing program on nutrition

Explanation	Sum of squares	d.f.	Mean square	F	5 percent point
Urban vs. farm residence.	6.61	1	6.61	.27 (n.s.)	F(1,75) = 3.97
Male vs. female sex.....	86.11	1	86.11	3.55 (n.s.)	F(1,75) = 3.97
Sex-residence categories, interaction.....	52.81	1	52.81	2.18 (n.s.)	F(1,75) = 3.97
Test sequence difference..	2.12	1	2.12		
Within groups residual....	16.73	3	5.58	.22 (n.s.)	F(3,72) = 2.73
Exp. groups subtotal..	164.29	7	23.47		
Individuals within groups.	1,801.70	72	25.02		
Grand mean.....	1,911.01	1	1,911.01	76.27 (Sig.)	F(1,72) = 3.98
Total.....	1,965.99	80	25.58		

analyzed were no more disperse than would be expected for six samples from the same population. The acceptable inference from this finding will be discussed below.

The F-ratio for "test sequence difference" was not significant for the program on nutrition. However, for the program on soil tillage, this F-ratio was significant at the .05 but not at the .01 level. As indi-

TABLE 2—Variance in Cloze Procedure difference scores after viewing program on soil tillage

Explanation	Sum of squares	d.f.	Mean square	F	5 percent point
Urban vs. farm residence.	21.01	1	21.01	.75 (n.s.)	F(1,75) = 3.97
Male vs. female sex.....	12.01	1	12.01	.43 (n.s.)	F(1,75) = 3.97
Sex-residence categories, interaction.....	5.51	1	5.51	.20 (n.s.)	F(1,75) = 3.97
Test sequence difference..	277.52	1	277.52	9.93 (Sig.)	F(1,75) = 3.97
Within groups residual....	36.13	3	12.04	.42 (n.s.)	F(3,72) = 2.73
Exp. groups subtotal..	352.19	7	50.31		
Individuals within groups.	2,059.70	72	28.61		
Grand mean.....	2,279.11	1	2,279.11	79.67 (Sig.)	F(1,72) = 3.98
Total.....	2,411.89	80	30.15		

cated previously, Form A of the Cloze Procedure test was used systematically as a pre-test in half the groups and as a post-test in the other half. This significant F-ratio indicates that Form A and B of the soil tillage test were not of equal difficulty. The advantage of the experimental design adopted becomes evident. Since analysis of variance permits the effect of test sequence to be "pulled out," this factor does not contaminate the findings which follow (Dixon and Massey, 1951).

When learning by men and by women was examined, the F-ratios revealed no statistically significant differences at the .05 level for either the sample program on nutrition or on soil tillage. However, the size of the mean square for learning differences by sex for the program on nutrition was so large as to result in an F-ratio approaching the .05 level. While the data indicate no statistically significant difference between sexes, the numerically larger learning scores for the men deserve mention here.

When learning according to place of residence was examined, the F-ratios revealed no statistically significant differences at the .05 level for either the sample program on nutrition or on soil tillage.

There remained the possibility that farm men, for example, might be more interested in the program on soil tillage than were urban women. Examination of such dependent relationships between the two factors revealed no statistically significant differences at the .05 level for either of the programs.

Attitude Shift. Results of shift in attitude regarding concepts (subject matter) for both the program on nutrition and soil tillage will be reported first. For the program on human nutrition, a statistically significant shift in attitude on the part of the general audience toward four of the six concepts measured was obtained. The concepts were,

TABLE 3—Groups with desired attitude shift toward "quickie diet" from viewing program on nutrition

	Male	Female	Total
Urban	2 of 2	1 of 2	3 of 4
R Non-F(*a*)	1 of 2	1 of 2	2 of 4
Farm	2 of 2	2 of 2	4 of 4
Total	5 of 6	4 of 6	9 of 12

(*a*) Rural Non-Farm.

TABLE 4—Groups with desired attitude shift toward "larger soil particles" from viewing program on soil tillage

	Male	Female	Total
Urban	2 of 2	2 of 2	4 of 4
R Non-F(*a*)	1 of 2	1 of 2	1 of 4
Farm	1 of 2	2 of 2	3 of 4
Total	3 of 6	5 of 6	8 of 12

(*a*) Rural Non-Farm.

in the order of magnitude of shift, as follows: QUICKIE DIET, CENTRAL BODY CORE, RESPIRATION METER, and WEIGHT CONTROL. Those concepts where no significant shift was noted included HUMAN NUTRITION and CALORIES. All shifts of attitude relating to concepts were in the desired direction.

The above statements indicate that a sufficient number of the 12 groups shifted their attitude toward QUICKIE DIET, for example, so that the general audience shift could not be attributed to chance alone. The .05 criterion established called for significant shifts on the part of three of the 12 groups. Thus the possibility remained that all the shifts might take place within a single residence or sex category.

Examination of the nine groups which shifted their attitude toward QUICKIE DIET in Table 3 reveals that the shift occurred regardless of sex or place of residence or any combination of these factors. This does not suggest that all groups reacted identically.

For the program on soil tillage, a shift in attitudes on the part of the general audience was again observed. In this instance, attitudes toward three of the five concepts measured were found to have shifted as a result of viewing the program. These concepts, in the order of magnitude of shift, were: LARGER SOIL PARTICLES, MINIMUM SOIL TILLAGE, and FIELD WEIGHING APPARATUS. Concepts where no shift was noted included WEED CONTROL and GROWING SEASON. All shifts noted were in the desired direction.

Here again, the shifts in attitude were not limited to any one category. As indicated in Table 4, the eight groups which shifted their attitudes toward LARGER SOIL PARTICLES were divided according to sex; and urban and farm categories. Comment on the shift in attitude toward the concepts measured will follow.

In turning to analysis of the sources (who said it), two questions were in order: (1) Were MICHIGAN STATE UNIVERSITY, AGRI-

CULTURAL RESEARCH, and the COUNTY AGENT looked upon with much favor to begin with? and (2) What effect did the two sample programs have on the way the general audience evaluated these sources of information? In answer to the latter question, analysis revealed that neither program resulted in a significant shift of attitude on the part of the general audience regarding any of the sources.

To answer the former question, the average evaluative factor score from the post-test of each program was examined. The scores for the concepts obtained from the post-test on the nutrition program were similar to the scores for the same concepts obtained from the post-test on the soil tillage program.

TABLE 5—Attitude toward sources of agricultural information after viewing program on soil tillage

	Scale score(*a*)	Number of 12 groups shifted
Michigan State University	6.36	1
Agricultural research	6.29	1
County agent	5.90	2(*b*)

(*a*) Scale range of maximum (7.00) to minimum (1.00).
(*b*) Shift of fewer than three groups was not considered a significant effect on general audience attitude.

Program Appeal

Examination of the profile data resulting from use of the WKAR-TV Program Analyzer was made to answer such questions as: Did all groups like or enjoy the program while it was presented? Was the degree of liking equal for all groups? Was one program liked better in general than the other?

The evidence of the rather substantial impact of the two sample programs of the County Agent television film series in terms of learning and attitude shift suggests that the programs were probably liked at least moderately well by all groups of the general audience. Such, in fact, was the case, according to analysis of the profile data.

The Subjects were asked to react to a scale by pointing the indicator knob to $\underline{1}$ to indicate "dislike much," to $\underline{3}$ to indicate "indifferent," and to $\underline{5}$ to indicate "like much." The average score of each group for the entire program rated, fell at or slightly less than a score of $\underline{4}$ on the scale. This was true for both sample programs.

However, although the average score for the entire program did

TABLE 6—Tetrachoric coefficients of correlation between sex and residence group profiles for program on nutrition

	Urban		R Non-F(*a*)		Farm
	M	F	M	F	M
			("Like-dislike" scale)		
Urban F	− .12				
R Non-F(*a*) M	+ .54				
R Non-F(*a*) F		+ .28	+ .41		
Farm M	+ .65		+ .54		
Farm F		+ .79		− .12	+ .65
			("Learning-not learning" scale)		
Urban F	+1.00				
R Non-F(*a*) M	+ .79				
R Non-F(*a*) F		+1.00	+ .79		
Farm M	+1.00		+ .79		
Farm F		+1.00		+1.00	+1.00

(*a*) Rural Non-Farm.

not vary much among groups, inspection of the peaks (segments liked) and valleys (segments disliked) along the profile suggested the groups were not of one mind in their judgment as shown in Table 6. Information obtained during the group interview indicated that some of the women's groups had recently participated in club meetings where nutrition and diets had been adopted as a topic of study.

The same moderate pattern of agreement was found between groups as to which segments of the program on soil tillage were "liked much." Here again the group interview revealed a varying degree of familiarity with the recently announced procedure for minimum soil tillage.

In contrast to the moderate correlation between groups observed when the Subjects rated the nutrition program according to the "like-dislike" scale, a very high degree of correlation between groups was observed, as shown in Table 6, when the same program was rated on the "learning-not learning" scale. The same was true of the program on soil tillage. A discussion of the significance of the viewers' relative subject-matter familiarity will follow.

When the mean score for all groups rating the program on the "learning-not learning" scale was computed for each program, no statistically significant difference was observed between nutrition (2.40) and soil tillage (2.50). When the mean score for all groups

rating the program on the "like-dislike" scale was computed, the difference was statistically significant between nutrition (3.66) and soils (4.06) at the approximate .05 level.

The data from the "learning-not learning" scores agree with the indirect findings on the Cloze Procedure tests that gain in learning appeared about equal from both programs. On the other hand, the profile data indicate that the program on soil tillage was preferred by all groups over the program on nutrition. Comments on program preference made during the subsequent group interviews by the majority of Subjects were in agreement with this finding.

DISCUSSION

Several questions of evaluation and interpretation remain after the presentation of the results of the study. These concern the comparison of learning achieved from each program, an evaluation of the operational importance of attitude shifts measured, and the relation of subject-matter familiarity to program appeal and program impact.

The question of learning achievement resulting from viewing the two sample programs was of particular interest to the producers, who had felt that the programs were the result of different production techniques. The results of the Cloze Procedure measures of learning could not be shown to differ, and WKAR-TV Program Analyzer "learning-not learning" ratings showed no statistically significant difference between the two programs.

The producers were hopeful of achieving a shift toward the sources MICHIGAN STATE UNIVERSITY, AGRICULTURAL RESEARCH, and COUNTY AGENT; but such a result would not have been predicted from previous research efforts on the Semantic Differential (Osgood et al., 1957). Stated in non-technical terms, these sources laid their favorable reputation on the line in endorsing the concepts promoted in the program series. As a result, the shifts were observed among the concepts, not the sources.

The possibility of a shift in a "more favorable" direction was limited in this study, quite aside from the above consideration. The ratings given these concepts by the general audience were about as high as could possibly be given.

That the programs failed to produce a shift in attitude toward all the concepts measured is not considered by the writer a serious criticism of the impact of the series. The producers indicated in advance

the key responses they wished to encourage were: "quickie" diets are dangerous, and larger soil particles are desirable in modern soil tillage. These attitude shifts were achieved, and clusters of related attitudes shifted along with them. Additional research in this field is necessary before a criterion of effectiveness can be established; none now exists.

"There may be times when it is important to cover a broad subject . . . but it is usually better to confine one's self to a **part** that can be **well treated** in the time allowed (emphasis supplied)" (Winans, 1938). It is suggested that the findings of this study pertaining to the extent of subject-matter familiarity constitute experimental evidence in agreement with the above statement.

These findings appear to indicate that the decision of the producers to confine themselves to consideration of a small part of the broad subject of human nutrition, namely, the dangers of the "quickie" diet was a wise one. It enabled them to treat that part so well and so comprehensively that, regardless of previous familiarity, all groups found their knowledge expanded and their attitudes changed as a result of viewing the sample program.

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STUDIES ON MUSKMELON AND TOMATO RESPONSES TO POLYETHYLENE MULCHING[1]

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THE USE OF VARIOUS materials as mulches on horticultural crops has been investigated periodically for over 75 years. Early experiments with asphalt paper proved so effective in controlling weeds in pineapple that by 1927 about 80 percent of the Hawaiian crop was mulched (Hartung, 1926).

Soon afterwards, interest in its use on vegetables developed in this country. Both asphalt and kraft papers were tested extensively during the late 1920's and early 1930's. Some of the asphalt papers used contained materials that were toxic to plant growth, the kraft papers deteriorated before the end of the season, and both types were easily torn (Magruder, 1930). Nevertheless, many instances of earlier harvests and greatly increased yields from the use of mulch paper on warm-season crops are recorded (Rowe-Dutton, 1957).

In Michigan in 1929, Edmond (1929) compared the yields of crops from areas completely covered with asphalt paper with those from areas that were given ordinary cultivation. Mulching increased the yield of warm-season crops; cucumbers and tomatoes by 180 percent, peppers by over 100 percent, and beans by 80 percent. It had little or no effect, however, on sweet corn, cabbage, or lettuce. Interest in mulching in Michigan was also evidenced in the development of a machine for laying asphalt paper (Musselman, 1929).

In the early 1930's most of the eggplant growers in Virginia were using asphalt mulch paper to hasten the maturity and increase the yield of the crop. However, during the depression years the use of the practice in commercial operations almost completely disappeared,

[1]The authors wish to acknowledge the cooperation of the Bakelite Company in supplying film, equipment for laying the plastic, and the photographs for Fig. 1, 2, 3 and 4; we also recognize the cooperation of Willard Wiltse and Robert Goodrich in various phases of the work.

ARTICLE 40-88

due to economic conditions and a shift in vegetable acreages to areas that partially eliminated premium prices for early maturity.

Interestingly, mulching, using a new synthetic product, black polyethylene, is being reevaluated 30 years later. This time it may find a more permanent place in vegetable production. Polyethylene is nontoxic to plant growth and resistant to decomposition by either moisture, light, or soil organisms. It is somewhat elastic and stretches rather than tears, and is as cheap as the products of 30 years ago.

To obtain information on the effects and possible economic advantages of using black polyethylene in the production of warm season transplanted crops, various tests have been conducted during the past 2 years.

TESTS WITH BLACK POLYETHYLENE MULCH ON MUSKMELONS

Muskmelon experiments with black plastic were conducted in 1957 on the horticulture farms at both East Lansing and in southwestern Michigan near Sodus, and on the Willard Wiltse farm near Howell.

At the three locations, banded plants were set at intervals of about 5 feet through plastic-covered rows spaced 6 or 7 feet apart, and

Fig. 1. View of tractor-mounted attachment for laying black plastic. The mulch was laid on the Wiltse farm by the Bakelite Company.

compared with plants set normally. The plastic used was 4 feet wide and 1.5 mils thick; when tucked into the soil at the edges, it covered approximately 50 to 60 percent of the area.

Fig. 1 shows the method of laying the plastic at Howell with the aid of a tractor-mounted attachment loaned by the Bakelite Company. Fig. 2 shows the melon plants on film and soil on June 29, 15 days after transplanting. At the other two locations, the film was laid by hand in 60- to 70-foot strips. In all areas a suitable fertilizer application was broadcast before the plastic was laid.

Small slits were cut at frequent intervals in the film to allow water penetration. Rainfall at East Lansing was as follows: June, 2.2 inches; July, 8.4 inches; and August, 1.4 inches. There was a concentrated period of rainfall of 6.8 inches from July 5 to July 13. Similar rainfall occurred at the other two locations. During the low rainfall in August, all of the plots at Sodus and Howell and one-half of the plots at East Lansing were irrigated.

Plots in each test contained five, six, or seven two-plant hills in a randomized replicated arrangement using two varieties of muskmelons. In addition, at East Lansing, the experiments included plots of both

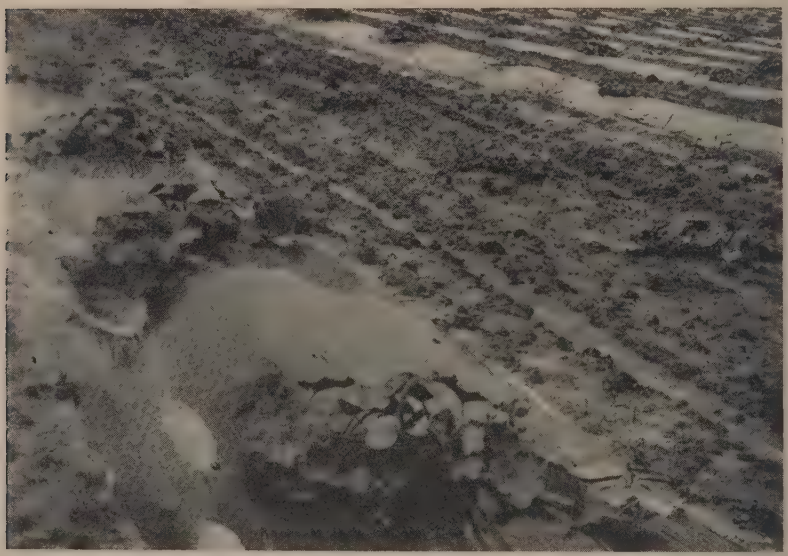

Fig. 2. These melon plants were planted on plastic mulch and soil in alternate rows. The picture was taken 3 weeks after field setting banded plants at Wiltse farm.

Fig. 3. Cultivating between plastic covered rows of small melon plants with a small hand-operated tiller.

varieties seeded under "hot tents" on the day the banded plants were set.

Uncovered plots were cultivated with tractor-mounted equipment, with sweeps that stirred the soil to within 6 inches of the plants at an early stage of growth. They were hoed and weeded by hand in the uncultivated portions of the row. Mulched plot row middles were cultivated with a small tiller, Fig. 3.

Results With Melons

The data in Table 1 indicate the cumulative seasonal average marketable yields harvested from August 16 through September 16 at each of the three locations from plastic-covered and control plots. The percentage yield increases for treatment through each picking date are shown and were statistically significant when tested at mid-season and at the end of the harvest period.

At East Lansing, data on average yields from irrigated and unirrigated plots, show that the mulch treatment not only resulted in greater total yields, but that a higher percentage of the yield was harvested early. Presumably the Honey Rock variety was benefited more than

the later maturing Harvest Queen in both respects. The increase in total yield from the use of plastic amounted to 172 bushels per acre with the Honey Rock variety and 156 with the Harvest Queen.

At East Lansing, melons seeded under "hot tents" at the time plants were set in adjacent rows in soil and on plastic, produced total yields of 251 bushels to the acre in the Honey Rock variety and 247 bushels in Harvest Queen. It is probable that a more favorable showing for "hot tents" would have been obtained if plants instead of seed had been used.

At Sodus, the increases from plastic were large at both the beginning and at the end of the season, but very small on August 29. Probably moisture became limiting at about this time and fruits on the uncovered plots ripened prematurely. This increased their yield, relative to the plastic covered plots where the moisture problem was less critical and the crop was allowed to develop more slowly.

When the plastic-treated plots were compared to the controls at Sodus, Harvest Queen variety outyielded Honey Rock by 237 to 125 bushels per acre. Most likely, the late variety, Harvest Queen, was

TABLE 1—Seasonal yield of muskmelons as influenced by black polyethylene mulch (yields in 50-lb. bushels per acre)

Yield to:	At East Lansing, Mich.			At Sodus, Mich.			At Howell, Mich.		
	On plastic	On soil	Percent increase	On plastic	On soil	Percent increase	On plastic	On soil	Percent increase
	Honey Rock variety			Honey Rock variety			Honey Rock variety		
Aug. 16	...	...	...	79	46	72	...	...	...
19	...	...	...	114	80	39	...	...	...
21	140	33	320	146	93	57	89	10	750
23	279	109	157	156	106	47	157	26	498
26	330	151	119	163	123	32	286	80	257
29	349	157	122	191	160	19	401	180	123
Sept. 3	382	214	79	301	214	41	440	203	117
6	394	222	78	342	232	47	...	...	...
9	420	231	82	345	238	45	451	218	107
13	429	242	77	363	238	52	...	...	...
16	429	257	67	...	...	...	...	...	...
	Harvest Queen variety			Harvest Queen variety			Burpee Hybrid variety		
Aug. 16	...	...	...	14	5	180	...	...	...
19	...	...	...	18	5	260	...	...	...
21	...	...	...	...	...	...	187	30	529
23	14	6	137	35	11	218	296	89	232
26	132	63	110	105	55	91	386	134	188
29	199	92	114	169	142	19	419	215	95
Sept. 3	341	175	96	332	205	62	437	263	66
6	377	190	98	377	205	84	...	...	...
9	392	223	76	434	211	105	437	300	46
13	418	241	73	448	211	112	...	...	...
16	436	280	55	...	...	...	...	...	...

F values significant at the 5 percent level for early and total yield.
Early yield: through August 29 at East Lansing, and Howell, and through August 23 at Sodus.

Fig. 4. Fruit set on typical mulched and unmulched plants on August 10 at Wiltse farm. Upper left: mulched Honey Rock; upper right: unmulched Honey Rock; lower left: mulched Burpee Hybrid; lower right: unmulched Burpee Hybrid.

either protected more on plastic or injured more on the control plots than Honey Rock during the dry period.

At Howell, the Burpee Hybrid variety was included in the test. Its relative high yield performance on plastic early in the harvest season, compared with Honey Rock, may have been associated with a greater metabolic response to the heat in the plastic-covered soil. The total yield of Burpee Hybrid on plastic was less than that of Honey Rock, but on soil it was more. However, on August 21 at the first harvest, Burpee Hybrid yielded 157 bushels more on plastic than on soil, while the Honey Rock produced only 77 more bushels per acre on plastic than on soil. Fig. 4 indicates the relative set of fruits on plastic and soil at Howell for the two varieties on August 10.

Influence of Irrigation in Combination with Plastic

The test at East Lansing contained replicated irrigated and unirrigated plots of each of the other treatments. The data in Table 2 indicate that the interactive effect of the combination treatment (plastic and irrigation), under the conditions of the experiment, was much greater than the additive effects of both factors considered independently.

TABLE 2—Interactive influence of plastic and irrigation on muskmelon yields, at East Lansing (yields in 50-lb. bushels per acre)

	Non-irrigated			Irrigated		
	Plastic	Soil	Av.	Plastic	Soil	Av.
			Honey Rock variety			
Early yield (*a*) ...	261	180	221	460	183	322
Late yield.....	58	71	64	79	79	79
Total.....	319	251	285	539	262	401
			Harvest Queen variety			
Early yield.....	293	169	232	230	80	155
Late yield.....	82	117	100	268	195	231
Total.....	375	285	331	497	275	386
Av. both varieties.	347	268	308	518	268	394

(a) Early yield to Aug. 29.
F values significant for plastic vs. soil and the interaction of mulch x irrigation.
Inc. for irrigation..... 0 (268 vs. 268).
Inc. for plastic..... 79 (347 vs. 268).
Inc. for both..... 250 (518 vs. 268).

In the early-maturing Honey Rock variety grown on unirrigated soil, the use of plastic increased the early yield by only 80 bushels to the acre. The increase on plastic under irrigated conditions amounted to 277 bushels. Neither irrigation nor plastic had an effect on the late yield of Honey Rock melons harvested after August 29.

In the later-maturing Harvest Queen variety, irrigation resulted in a decrease in early yield regardless of whether or not the plants were grown on plastic. However, the late yield of Harvest Queen, in contrast to that of Honey Rock, was influenced by both irrigation and plastic in the same manner as was the early yield of Honey Rock.

It is possible that the heavy rains in July differentially influenced variety response depending on some inherent difference in variety.

Or the effect may have been due to a difference in the stage of growth at the time of the drouth.

In 1957, irrigation did not help the melon crop unless the plants were grown on plastic; then the combined effect resulted in an increase in yield of over 90 percent. Perhaps mulch reduced a temporary damaging effect of heavy rains or irrigation on soil aeration phenomena, which in turn allowed a more optimal metabolic activity in the plant's roots. Emmert (1957) recently observed a similar effect that irrigation had in tomato and some pole bean experiments.

Mulching Influences Fruit Weight and Number in Muskmelons

The increases in yield in terms of marketable weight per acre from the use of plastic mulch on melons may be due to either more and/or larger fruits as indicated by data in Tables 3 and 4. In the Honey Rock variety at East Lansing, irrigation resulted in an increase in the size of the early maturing fruit on plastic, but decreased it on soil.

At Sodus, early fruits of both the Honey Rock and the Harvest Queen varieties were of about the same weight as those produced at East Lansing. However, later-harvested fruits were almost one-third larger than those grown at East Lansing when produced on plastic, but of about the same size when grown on soil. At East Lansing, in the Harvest Queen variety, irrigation increased the size of late maturing fruits and plastic had no influence on fruit size.

An increase in both fruit size and number was responsible for the

TABLE 3—Effect of treatment on fruit weight (pounds per fruit)

	At East Lansing						At Sodus	
	On plastic			On soil			On plastic	On soil
	Irrig.	Non-irrig.	Av.	Irrig.	Non-irrig.	Av.		
	Honey Rock							
Early.....	3.3	3.0	3.1	2.7	3.0	2.8	2.9	2.4
Late.....	2.8	3.2	3.0	3.0	3.0	3.0	3.9	3.3
Total...	3.1	3.0	3.1	2.9	3.0	2.9	3.4	2.8
	Harvest Queen							
Early.....	3.3	3.2	3.2	3.3	3.2	3.2	3.4	3.7
Late.....	3.8	3.2	3.7	3.9	3.3	3.8	5.1	3.7
Total...	3.6	3.2	3.4	3.6	3.3	3.5	4.9	3.7

TABLE 4—Percent increase in number, weight, and total yield of melons as influenced by plastic mulch

	At East Lansing			At Sodus		
	No.	Weight (*a*)	Total yield	No.	Weight (*a*)	Total yield
Honey Rock.....	56	7	67	26	21	52
Harvest Queen...	59	−2	55	61	33	112

(*a*) Weight per fruit.

increase in yield from plastic mulching (Table 4). At East Lansing, where moisture was not limiting, the increase in yield was due almost entirely to an increase in the number of fruits. However, at Sodus, where moisture may have been limiting during a part of the season, plants grown on plastic produced both more and larger fruits than were harvested from uncovered plots.

A COMPARISON OF THE EFFECT OF PLASTIC AND HOT TENTS ON TOMATOES

The premium prices paid for early tomatoes has resulted in a continual search for suitable practices that will hasten their maturity. An experiment was conducted in 1957 to compare the value of plastic mulch and "hot tents" with normal planting on the early and total yield of the crop, both with and without irrigation. Two varieties were used in the experiment. Twelve Fireball plants were spaced 28 inches apart; nine Moreton Hybrid plants were spaced 42 inches apart. Both were set in rows 6 feet apart. These plots were replicated in a randomized block design.

Large flat-grown plants were field set on May 18 in all plots. Four-foot widths of 1.5 mil plastic and "Super Hot Tents" were used. Cultivation practices were similar to those followed in the melon tests. The plots designated for irrigation treatment were watered when drouth threatened in August.

Results

Fruit was harvested from July 25 thru September 29, counted, graded, and weighed. The results of the various treatments are reported in Table 5 and consist of the marketable yields calculated in terms of bushels to the acre. As expected, the two varieties yielded

differently; but neither, on the average of all treatments, indicated a significant response to irrigation. The use of "tents" did not improve earliness or yield in this test where neither cold, windy, nor quiet, frosty nights were encountered.

In the earlier Fireball variety, early yields on plastic were 60 percent higher in unirrigated areas and 65 percent higher in irrigated areas than on uncovered soil. Total yields from plants grown on plastic, compared with those grown on soil, were 78 percent higher in unirrigated areas and 95 percent higher in irrigated areas.

In the Moreton Hybrid variety, similar but less striking, responses to plastic were recorded. Plastic-grown plants yielded 18 percent more early fruit on unirrigated and 37 percent more on irrigated plots. Total yields on plastic were increased by 47 percent on unirrigated plots, and by only 31 percent on irrigated plots. This effect of irrigation in reducing the influence of plastic was not observed in melons, and suggests that the tomato may be more tolerant to both drouth and excessive moisture than the melon crop.

In Table 6 the figures indicate that a considerable portion of the increase in yield due to plastic is associated with an increase in size. At the end of the season, after several killing frosts had occurred, the

TABLE 5—Interactive influence of plastic and irrigation on tomato yields (marketable yields in 60-lb. bushels per acre)

	Non-irrigated				Irrigated			
	Plastic	Tent	Soil	Av.	Plastic	Tent	Soil	Av.
	Fire Ball variety							
Early yield (*a*)....	314	218	197	243	335	186	204	242
Late yield.....	283	192	138	204	303	169	124	199
Total yield....	597	410	335	447	638	355	328	440
	Moreton Hybrid variety							
Early yield.....	304	238	258	267	314	234	228	265
Late yield.....	673	422	392	496	646	518	500	555
Total yield....	977	660	650	762	960	752	728	813
Av. both varieties .	787	535	493	605	799	554	528	627

Inc. for irrigation..... 35 (493 vs. 528).
Inc. for plastic..... 294 (787 vs. 493).
Inc. for both..... 271 (799 vs. 528).
(*a*) Early yield to Aug. 15.
F values significant for plastic vs. soil, plastic x variety, harvest period and harvest period x irrigation x variety.

TABLE 6—Influence of treatments on average fruit and plant weight of tomatoes in pounds

	Non-irrigated			Irrigated		
	Plastic	Tent	Soil	Plastic	Tent	Soil
Fireball wt/fruit.....	.309	.28	.287	.321	.304	.287
wt/plant (*a*).....	1.750	.59	.500	1.670	1.190	1.300
Moreton H. wt/fruit.....	.443	.394	.398	.439	.438	.413
wt/plant (*a*) .	5.550	3.47	2.330	5.770	4.050	3.620

(*a*) Obtained by pulling plants at end of season after many of the leaves had fallen, and the plants were partially dried.

plants were pulled from the various plots and after removing the green fruit, were weighed. The values for plant weights shown in Table 6 consist mainly of large root and stem material.

There were striking increases in plant weight associated with plastic mulching and irrigation. On unirrigated plastic-covered plots of Fireball, this increase amounted to 250 percent, and on Moreton Hybrid to 138 percent. Irrigation on uncovered plots resulted in an

Fig. 5. Moreton Hybrid tomatoes showing difference in plant growth at time of first picking on mulched plot (left) and unmulched plot (right).

increase in residual plant weight at the end of the season of 160 percent in Fireball and of 56 percent in Moreton Hybrid. Fig. 5 indicates the difference in plant growth resulting from plastic mulching.

As a large plant that maintains its vigor to the end of the season is associated with adequate foliage cover, which in turn is related to well colored, high quality fruit, it is probable that both quality and yield were enhanced by plastic mulching. Perhaps the increased vegetative growth from plastic is related to an increase in nitrogen availability to the plant roots due to the influence of the higher temperature and the better aeration on nitrification.

GENERAL DISCUSSION OF MULCHING

On the basis of 40 published reports, reviewed by Rowe-Dutton (1957), cucurbits show more response to mulching than any other crop. In this study, melons also showed more response to plastic mulching than tomato.

A partial explanation for this effect is found in the difference in the type of root systems of the two plants. Weaver and Bruner (1927) observed that by mid-season, muskmelon plants normally have a very extensive, well-branched root system, spread laterally throughout the surface 4 to 8 inches of soil, with very few important major roots below a depth of 16 to 20 inches.

In tomato, they noted that the roots turned downward at a very early age and soon filled the soil on all sides of the plant to a depth of 2 or more feet. This inherent difference in rooting behavior of the two crops may be associated with differences in the oxygen requirement of their roots. Melon roots, apparently, develop most readily in the surface soil where aeration is more satisfactory and temperature more favorable than at lower depths.

Then, protecting the surface soil root system of the melon from injury due to cultivation and maintaining the surface soil at a more satisfactory moisture and temperature level by means of plastic mulch, should provide ideal conditions for melon plant development. Smith (1931) found that mulching with black asphalt paper increased soil temperature at depths of 3 to 12 inches from 3 to 5° F. over that observed on adjacent cultivated plots. At the soil surface, temperatures may be increased considerably more than 3 to 5° during sunny weather, but drop at night due to loss in heat from radiation. This drop in temperature causes condensation of moisture on the underside of the film and keeps the surface soil wet.

The difference in response of the melon and tomato crops to mulch with irrigation is another indication of their differential requirement for air and moisture. Although neither crop was significantly benefited by irrigation alone in these tests, irrigation substantially increased the effect of plastic on melons, but slightly reduced the influence of plastic on tomato production. Without the protective effect of plastic mulch, irrigation apparently, temporarily hampered aeration in the soil to an extent that the high oxygen requiring melon roots were injured more than the less sensitive tomato roots.

Under different climatic and soil conditions, the magnitude and nature of the differences observed with tomatoes and melons might well be materially modified. However, on the basis of these results, it appears that plastic mulching should prove beneficial under crops that are: (1) shallow rooted and/or (2) have roots that are benefited by higher temperatures, by higher soil oxygen or by abundant moisture in the surface soil. The most pronounced responses to plastic mulching, then, should occur on sandy soils of poor structure, in seasons of normal temperature and low rainfall where irrigation is practiced.

Functions of and Benefits from Mulching

Mulching with any material is primarily done to prevent weed growth and to conserve moisture. Materials that do not absorb or retain water or form a capillary system themselves are most efficient for moisture conservation. Opaque materials are necessary to prevent light penetration from stimulating weed growth. Materials that are darker in color than the soils on which they are used will increase surface soil temperature, those that are lighter will decrease temperature.

Where improper cultivation is practiced which prunes or removes much of the surface root system of shallow, laterally rooted plants, the use of mulch to eliminate the necessity of cultivation becomes one of its important functions. Frequently, the absence of roots in the surface 4 inches of soil due to deep cultivation prevents the crop from benefiting from a ½-inch rainfall which will not penetrate to its root system.

Sawdust and particularly straw mulches readily allow moisture penetration to surface roots; black polyethylene does not, unless small slits are cut in depressed areas to allow the water to drain into the soil. These slits act as valves, which open slightly with the weight of

water during a rain or irrigation and close fairly tightly after the water has passed through, thus preventing its loss by evaporation. It is probable that a polyethylene mulch, with well-arranged and properly-placed slits, will conserve more moisture than any other available type of mulching material.

Covering the soil nearest the plant with mulch, after proper fitting at an optimum moisture content, will prevent hard rains or irrigation from deteriorating its structure. This function of a mulch is of inestimable value, particularly on soils that are easily puddled or low in organic matter. It allows water to penetrate readily, which prevents it from interfering with a normal exchange of soil for atmospheric air. The roots of rapidly-developing vegetables probably have a higher oxygen requirement than any other groups of crops. Oxygen is required to liberate the energy required by the roots for cell division and growth, and to absorb both water and nutrients.

A combination of a slightly higher temperature, adequate moisture, and proper aeration, afforded by the use of black plastic mulch, in the surface six inches of soil in which the roots are allowed to develop normally, places the nutrients in the fertile top soil in the most favorable situation for maximum plant utilization. This combination of favorable factors is suggested as an explanation for the widely reported evidence that the cucurbits are benefited more by mulching than any other crop. The higher temperatures in the surface foot above a black mulch may also be of benefit to spreading warm-season vine crops.

The use of aluminum, straw, or sawdust would also promote better moisture and aeration conditions in the top soil, but at a reduced temperature which should be favorable for the development of cool-season crops. In addition, these materials will reflect more of the sunlight falling on them which may improve the photosynthetic efficiency and the health of the lower leaves of taller crops.

With the use of mulches, most of the hand labor required in controlling weeds is eliminated. Careless, inexperienced labor on a tractor cultivator or with a hoe in their hands not only generally damage plant roots, but frequently injure the foliage as well, and occasionally even cut off the crop they are hoeing. These hazards to tender crops are largely eliminated by mulching.

Further, mulching reduces the spread of disease by cultivation and from infected soil splashing on the crops. Although there was little evidence of it in the experiments conducted, it is probable that

mulching under many conditions may not only keep the produce cleaner, but also reduce losses and quality from injury by soil diseases and insects.

Economic and Other Problems with the Use of Mulches

Mulches are expensive; the plastic required to cover two-thirds of the area on an acre at present prices will cost from $125 to $150. For many crops there are other ways of improving yield which, in some cases, may be almost as effective and much less expensive.

Ries (1957), in a recent study with pickling cucumbers, found that black plastic increased the yield of fruit over that produced on plots receiving deep, normal cultivation by 21 percent. However, in the same test, chemical weed control increased the yield by 19 percent, and shallow cultivation, using sweep instead of shovel attachments, increased the yield by 18 percent. Careful attention to cultivation, using suitable equipment at the proper time or adapted weed control chemicals, could modify one of the important advantages of mulching on some crops.

Irrigation with proper nozzles and pressures to produce small drops will help eliminate the damaging effect of falling water on soil structure. Timely applications of water, previous to the appearance of noticeable drouth symptoms, would help serve one of the functions of mulching. If more careful attention had been paid to the timing of irrigation in this study, it is probable that at Sodus, the effectiveness of mulching would have been reduced. However, mulching will minimize the effect of the lack of proper timing of irrigation, and should increase its profitableness under most conditions.

The maintenance of a high state of tilth by maintaining the organic matter through suitable rotation, green manuring, and cover cropping practices would eliminate some of the advantages to be gained by mulching. However, as in the case with irrigation, under many conditions, mulching may increase the profitableness of these practices.

In crops that must be hand-hoed at considerable labor expense, mulching may reduce the cost of production. In general, the cost of laying a mulch, the additional time involved in planting on it, and the precautions necessary in spraying and in cultivating row middles of mulched areas, should about balance the cost of hand and tractor labor involved in keeping an unmulched area weed free.

For the commercial grower that wishes to mulch several acres, a tractor-attached applicator (Fig. 1) is a necessity if a smoothly-

covered bed of well-anchored film is to be applied economically. Hand mulching on a large scale is not advisable. Plants set on plastic are more easily injured by low temperatures, and frosts because the soil heat is held by the mulch. Consequently, crops cannot be safely planted as early on plastic as on uncovered soil.

Black plastic mulch of 1.5 mil thickness will not completely prevent the sharp spikes of quack and nut grass from growing through it. The material is resistant to decomposition and should be removed from the field unless it can be preserved in place for use another season. Whether the mulch can be maintained in place and the crop residues economically removed, or worked into the soil between the plastic-treated rows in large scale operations, has not been investigated.

Mulching will prove most profitable on high valued warm season crops; i.e. muskmelon, cucumber, early squash, tomato, pepper, eggplant, and perhaps with sweet potatoes, early beans, and okra, where all other practices necessary for optimum crop production are followed carefully, fertile soils are used, and a premium market for earliness and high quality are available.

The use of plastic mulch should find considerable favor among home and hobby vegetable and flower gardeners whose enthusiasm and energy frequently wane during the summer when hot, dry weather and weeds threaten to eliminate their crops.

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A STUDY OF MALATHION FOR CONTROLLING FLIES IN DAIRY BARNS AND ON DAIRY CATTLE

By A. L. WELLS[1], Z. STELMACH[2], G. E. GUYER[1], and E. J. BENNE[2]

DAIRYMEN NEED a safe and effective means of controlling flies in their barns and on their animals. Malathion seemed to offer promise of filling this need. However, this insecticide may contaminate the milk (Claborn, 1956; Claborn et al., 1956) and inhibit the cholinesterase activity in the blood (Hamblin et al., 1956). Thus, it was decided to investigate the problem further under Michigan conditions.

During 1956 and 1957, a cooperative study was conducted by the departments of entomology, agricultural chemistry, and dairy at Michigan State University; and the American Cyanamid Company. The study sought first to determine the effectiveness of malathion for controlling flies in dairy barns and on dairy cattle. Two other purposes were to find out how much malathion enters the milk of lactating animals that receive dermal applications of it and what effects direct applications have on the cholinesterase activity of the blood.

The purpose of this paper is to present the details of the investigation and the results obtained.

EXPERIMENTAL PROCEDURE

1956

In 1956, twenty Holstein cows, in various stages of lactation and pregnancy, were used as test animals.[3] They were housed in a stanchion-type barn except for about 3 hours daily when they were released into a loafing yard. The barn had not been treated with insecticides since the previous fly season and received no treatments during 1956.

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To compare the effects of several treatments, the cows were divided into five groups of four cows each, and the different groups were treated with diluted sprays of premium grade malathion or with malathion dust as follows: (1) sprayed daily with 0.5 percent spray; (2) sprayed daily with 1.0 percent spray; (3) sprayed every 3 days with 1.0 percent spray; (4) dusted daily with 4.0 percent commercial dust; and (5) received no treatment and were designated as the control group.

The sprays were applied with compressed air sprayers of 1-gallon capacity at the rate of 1 quart of diluted spray per cow. The dust was applied with a rotary duster at the rate of 1.25 ounces per cow. All of the treatments were applied to the back and sides of the cows from the shoulders to the rump, including the legs, tail and udder, soon after the morning milking period.

The number of treatments each group received depended on the extent of cholinesterase inhibition in the blood of the cows. For the health of the cows, it was decided to discontinue treatments if the cholinesterase activity decreased 50 percent from the pretreatment level.

The effectiveness of the treatments for fly control was determined by keeping a daily check on the number of flies on the cows. The counts were made on the right sides of the cows from the shoulders back to the tail and down to the knee and hock each day before the treatments were applied. The fly populations were composed primarily of house flies (*Musca domestica* [L.) although stable flies (*Stomoxys calcitrans* [L.) were numerous at times.

Outline drawings of the markings on all of the cows were made to see if the flies were attracted to cows with certain markings more than others, as has been reported by Morrison et al. (1950).

The blood samples for the cholinesterase activity determinations were taken after the morning milking period of each sampling day. The samples were collected by veterinary medicine students from jugular veins into graduated tubes containing heparin as an anticoagulant.

After mixing the contents, the tubes were placed in crushed ice, transported to the laboratory, and centrifuged to separate the plasma from the erythrocytes. The erythrocytes were rinsed with saline solution and their cholinesterase activity was determined by the electrometric method of Michel (1949).

The cows were milked with a milking machine with all precautions taken to prevent contamination. The milk from each cow was weighed

and sampled for butterfat and malathion determinations. All of the samples for malathion analysis were taken during the evening milking period with the exception of the first two from the cows receiving the 1 percent sprays. These were taken from the morning milk.

The samples were collected in glass jars, transferred to plastic sacks, and stored at 0° to 5°F., where they remained frozen until they could be analyzed. The milk sampling was discontinued about 10 days after the last insecticide treatment of each group. From the results of studies by Claborn et al. (1956), it was assumed that the malathion would not remain in the animals' systems after this period.

The samples were analyzed for malathion by the colorimetric method developed by the American Cyanamid Company. This method has since been published by Norris et al. (1958). The final photometric readings were made with a Cenco-Sheard-Sanford photelometer, equipped with 1-centimeter absorption cells and a Corning No. 5113 filter of standard thickness.

1957

The 1957 fly control program was planned to study the effectiveness of malathion when applied to both cows and calves on a herd basis and to the barn as well.

In carrying out this program, about 40 gallons of 1-percent spray of premium grade malathion were applied to the sides and backs of 40 Holstein cows and 42 calves. It was also applied to the walls and ceiling of the 43,200 cu. ft. stanchion-type barn in which they were housed.

During the summer, five such applications were made at about 3-week intervals. Care was taken to prevent the spray from contaminating the feed mangers or drinking cups during the spraying operations. Each cow and calf received about 1 pint and ½ pint of spray, respectively, in each application.

Three cows were released from the barn for 2 hours during and after the spraying operations to serve as controls for the cholinesterase-activity and milk-contamination studies which were made concurrently with the fly-control program.

Blood samples for cholinesterase activity determinations were taken twice before treatment and at 3-week intervals during the testing program. The blood sampling technique and method of analysis were the same as in the 1956 research.

In 1957, milk samples for malathion analysis were taken before treatments had been made to the barn or cattle and usually from the succeeding milking periods after each treatment. Samples were taken from the untreated cows at the same time to determine if they had acquired any malathion from the barn. Samples of milk from three Holstein cows in another herd, which had never been treated with malathion, were taken periodically as additional controls.

All of the milk samples taken in this project were handled and analyzed by the same methods used in 1956.

RESULTS

1956

A comparison of the fly populations on the treated and untreated cows during the project period is given in Table 1. The data indicate that the applications of 1-percent sprays reduced the fly populations. However, statistical analysis indicated the differences for correspond-

TABLE 1—A comparison of the fly populations on treated and untreated cows for corresponding periods

Cows treated with	Average number of flies on right side of four cows (*a*)
½ percent spray daily (35 treatments) (*b*)	181 (*d*)
No malathion	164
1 percent spray daily (8 treatments) (*b*)	9 (*d*)
No malathion	29
1 percent spray every 3 days (17 treatments) (*c*)	
First day after treatment	41 (*d*)
No malathion	78
Second day after treatment	56 (*d*)
No malathion	78
Third day after treatment	57 (*d*)
No malathion	87
4 percent dust daily (22 treatments) (*b*)	133 (*d*)
No malathion	87

(*a*) Sum of daily fly counts.
(*b*) Counts begun on day after first treatment and completed on day after last treatment.
(*c*) Counts begun on first, second, and third days after first treatment and completed on first, second, and third days after last treatment, respectively.
(*d*) Differences not significant at 5 percent level.

ing days were not significant due to the wide variations in fly populations on the individual cows in each group.

Applications of ½-percent sprays did not decrease the fly populations on the treated cows. By comparison with untreated cows, the dust treatments seemed to attract flies to the animals, although this increase was not statistically significant.

There appeared to be no correlation between color patterns and the fly populations on the cows. The two untreated cows having the highest and lowest numbers of flies during the project had very similar markings. This was further shown by the fact that two of the cows treated with the dust were identical twins and had dissimilar populations.

The effects of the dermal applications of malathion on the erythrocyte cholinesterase activity of the cows are presented graphically in Fig. 1. The data indicate that the spray treatments decreased the cholinesterase activity continuously during the periods of applications. It was decreased more rapidly by the daily treatments than by those applied at 3-day intervals. The results show that regeneration of the cholinesterase activity started soon after termination of the treatments.

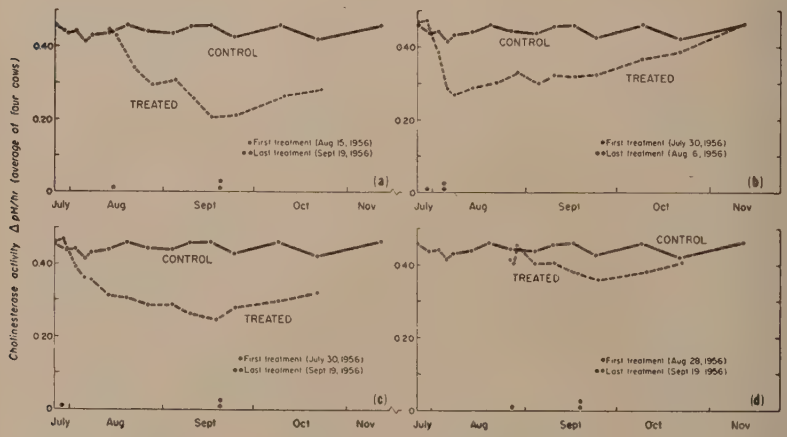

Fig. 1. Erythrocyte cholinesterase activity of treated and untreated cows during 1956: (a) ½ percent malathion spray daily (4.5 gm. malathion per cow per treatment); (b) 1 percent malathion spray daily (9 gm. malathion per cow per treatment); (c) 1 percent malathion spray every three days (9 gm. malathion per cow per treatment); (d) 4 percent malathion dust daily (1.4 gm. malathion per cow per treatment).

TABLE 2—Malathion in milk from cows treated daily with ½ percent spray (4.5 gm. actual malathion per cow per treatment)

Total treatments at time of sampling	Interval since last treatment	Milk from cow number								Average p.p.m.
		A-77		A-67		A-80		218		
		Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	
0	...	113	0	75	0	113	0	113	0	0
2	8 hr.	126	.01	28	.03	28	0	28	0	.010
5	8 hr.	76	.01	67	.01	76	0	76	0	.005
8	8 hr.	69	.05	64	.05	69	.01	121	.05	.040
15	8 hr.	110	0	57	0	17	.05	17	.08	.033
22	8 hr.	13	.01	15	.04	15	0	15	0	.013
30	8 hr.	55	.19	104	.23	55	.08	55	.20	.175
36	1 day	68	.03	46	0	46	0	46	0	.008
36	8 days	11	0	8	.01	8	0	6	0	.003

(*a*) Stored in frozen condition at 0° to 5°F. until analyses could be made.

As indicated in Fig. 1, the malathion dust had very little, if any, effect on the cholinesterase activity of the cows receiving these treatments.

Results of the analyses of the raw milk samples for malathion are presented in Tables 2 to 5. Each value shown in the tables is the average of results from duplicate determinations of a milk sample. Inasmuch as the milk samples could not be analyzed immediately after collection, they were stored in the frozen condition for the periods indicated in the tables.

No malathion was found in the milk from any of the cows before they were treated or from the untreated cows during the study.

TABLE 3—Malathion in milk from cows treated daily with 1 percent spray (9.0 gm. actual malathion per cow per treatment)

Total treatments at time of sampling	Interval since last treatment	Milk from cow number								Average p.p.m.
		A-78		A-95		K-129		A-98		
		Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	Days stored (*a*)	p.p.m. malathion	
0	...	15	0	9	0	12	0	12	0	0
1	20 hr.	10	0	2	.12	29	0	29	.07	.048
4	8 hr.	29	.15	29	.11	32	.07	9	.10	.108
6	8 hr.	31	.14	33	.12	33	.07	33	.16	.123
8	1 day	36	.08	36	.09	34	.11	36	.11	.098
8	4 days	35	0	35	.08	35	.10	48	0	.045
8	7 days	45	.02	46	.04	45	.02	46	.04	.030

(*a*) Stored in frozen condition at 0° to 5°F. until analyses could be made.

Table 4—Malathion in milk from cows treated every 3 days with 1 percent spray (9.0 gm. actual malathion per cow per treatment)

Total treatments at time of sampling	Interval since last treatment	Milk from cow number								Average p.p.m.
		568		A-94		K-139		K-303		
		Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	
0	...	15	0	9	0	15	0	12	0	0
1	20 hr.	8	.12	10	.01	10	.06	27	0	.048
2	8 hr.	(b)	...	29	.01	32	.17	(b)	...	.090
2	2 days	31	.02	31	.03	34	.06	34	.05	.040
3	2 days	35	.06	34	.10	35	.08	34	.09	.083
4	2 days	103	.08	43	.06	103	.04	103	.05	.058
5	2 days	115	0	115	0	115	0	135	.03	.008
6	2 days	126	.01	35	.07	125	0	125	0	.020
7	2 days	74	.03	34	.08	74	0	74	.04	.038
8	2 days	69	.06	33	.08	102	.01	102	.01	.040
11	8 hr.	17	.12	19	.19	26	.12	110	.03	.115
13	1 day	84	0	13	.03	13	.01	84	0	.010
16	8 hr.	62	0	11	.03	62	.02	62	.07	.030
18	1 day	41	.06	(b)	...	41	.01	41	.05	.040
18	8 days	6	0	84	0	11	0	8	.04	.010

(a) Stored in frozen condition at 0° to 5°F. until analyses could be made.
(b) Sample lost during analysis.

For both dust and sprays used, the amounts of malathion determined in the milk depended upon the frequency of application and the length of interval between treatment and sampling.

Eight days after terminating the treatments, malathion was either absent from the milk or was present only in greatly diminished amounts.

TABLE 5—Malathion in milk from cows treated daily with 4 percent dust (1.4 gm. actual malathion per cow per treatment)

Total treatments at time of sampling	Interval since last treatment	Milk from cow number								Average p.p.m.
		T-3		T-4		A-103		K-131		
		Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	Days stored (a)	p.p.m. malathion	
0	...	32	0	97	0	113	0	113	0	0
1	8 hr.	20	.02	111	.01	115	0	20	.07	.025
4	8 hr.	84	0	112	0	84	.03	84	0	.008
7	8 hr.	91	0	82	0	82	0	82	0	0
10	8 hr.	84	0	84	0	83	0	84	0	0
17	8 hr.	56	0	56	0	56	0	67	.06	.015
23	1 day	60	.09	68	0	68	.02	60	.05	.040
23	8 days	6	0	30	0	11	0	30	0	0

(a) Stored in frozen condition at 0° to 5°F. until analyses could be made.

Neither milk production nor body weights of the cows were affected by the malathion treatments. There were no apparent external symptoms which would indicate the malathion had a toxic effect on the cows.

1957

The malathion applications made during this study did not appear to exhibit the lasting toxicity to the fly populations which had been evident from investigations in previous years. Daily observations indicated that a high fly mortality resulted for 3 or 4 days after each application. This was followed by about 2 weeks of satisfactory control in the barn, after which the fly populations increased more rapidly than in previous years.

The effects of the treatments on the erythrocyte cholinesterase activity of the treated cows are shown in Fig. 2. The cholinesterase activity of the treated cows was consistently lower than that of the untreated cows throughout the testing period. The reason for the decrease in cholinesterase activity of some of the treated cows in October is not clear.

The malathion analyses of the milk samples are presented in Table 6. None of the samples were stored in the freezer more than 2 weeks before analysis, therefore the length of the storage period is not shown.

Although malathion was present in detectable amounts in the milk 8 hours after its application to the cows, it did not persist as

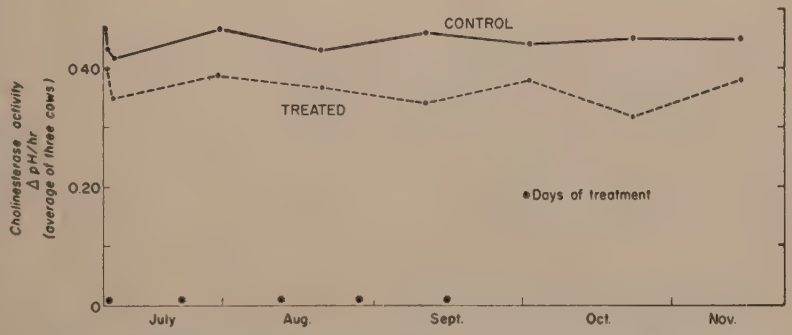

Fig. 2. Erythrocyte cholinesterase activity of cows treated with 1 percent malathion at three week intervals in 1957.

TABLE 6—Malathion in milk from cows treated with 1 percent spray at 3-week intervals in 1957

Total treatments at time of sampling	Hours since last treatment	Milk from cow number			Average p.p.m.
		A-76	K-128	T-17	
		p.p.m. malathion	p.p.m. malathion	p.p.m. malathion	
0	..	0	0	0	0
1	56	0	.02	.04	.020
2	32	0	0	0	0
3	15	.01	.04	.01	.020
4	8	.02	.01	.02	.017
4	20	.02	.02	0	.013
4	32	.01	0	.02	.010
5	8	(*a*)	(*a*)	.08	.080
5	20	0	.02	.03	.016
5	32	0	0	.01	.003

(*a*) Sample lost during analysis.

long as after the daily applications of 1-percent spray in 1956. The amounts in the milk resulting from the applications of the 1-percent spray every 3 weeks were similar to those caused by the daily applications of the ½-percent spray and 4-percent dust in 1956. This was possibly due to the comparable amounts of malathion applied to each cow.

It is unfortunate that two of the samples taken 8 hours after the fifth treatment were lost, since the value for malathion in the other sample seems excessively high.

SUMMARY

A study of malathion for controlling flies in dairy barns and on dairy cattle and its effects on the cattle was made in 1956 and 1957.

The results indicate that:

1. The application of malathion to cows only did not significantly reduce the fly populations on the cows.

2. The degree of fly control in the barn and on the cows and calves was satisfactory when the 1-percent spray was applied as a residual treatment every 3 weeks to the barn, as well as to the cattle.

3. The cholinesterase activity of the cows treated daily with 0.5-percent spray, 1.0-percent spray, and 4.0-percent dust, and every

3 days with 1.0-percent spray was inhibited for varying lengths of time, but returned to normal after termination of the treatments.

4. When the cattle and barn were sprayed every 3 weeks, the cholinesterase activity of the cows was inhibited immediately after treatment, but to a less extent than when the treatments were applied more often, as in 1956.

5. Malathion from all of the treatments was detected in the milk in varying small amounts, depending on the type of treatment and interval before sampling.

6. The milk production, body weights, and general external appearance and activities of the cows were not affected by any of the treatments.

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ACKNOWLEDGMENTS

The authors gratefully acknowledge the cooperation and help given by Dr. C. A. Lassiter and his colleagues from the dairy department in conducting this investigation. They wish to express their appreciation also to the American Cyanamid Company for supporting the investigation financially, for providing needed equipment, and for donating the services of Miss Florence Hermenze, who made the determinations for cholinesterase activity in 1956. Grateful appreciation is expressly extended to Mr. William Van Scoik of the above company for his assistance and cooperation throughout the study.

ECONOMICS OF GROWING AND IRRIGATING PICKLING CUCUMBERS

By *C. R. Hoglund*[1]

Department of Agricultural Economics

Irrigation has been used increasingly in recent years in the production of pickling cucumbers, potatoes, and other cash crops. Most of these crops are grown on the sandier soils of central and southwestern Michigan, hence, respond well to irrigation during seasons of low rainfall.

To learn more about the economic consequences of irrigation, 30 Montcalm County growers of pickling cucumbers and/or potatoes were asked to furnish information about their irrigation investments, practices, yields, receipts, and expenses during 1957. These farmers were visited about every 10 or 12 days to obtain seasonal information on all of their growing, irrigation, and harvesting practices.

Rainfall during June and July of 1957 averaged above normal in the area in which the pickling cucumbers were grown. August precipitation totalled less than 1 inch at the Edmore station. Rainfall during a 49-day period, July 23 to September 10, totalled only 2.4 inches on two farms on which rain gauges were placed. Most of the cucumbers were harvested during this period.

This article reports practices, yields, receipts, and expenses for eight non-irrigated and seven irrigated farms on which pickling cucumbers were grown. The results for irrigated and non-irrigated potatoes are given in a separate report.[2]

[1] Most of the field work was done by Bernard Brown and Dean Tribby. The author acknowledges helpful suggestions and assistance from E. H. Kidder of the department of agricultural engineering, S. K. Ries of the department of horticulture, and R. G. Wheeler of the department of agricultural economics. The author wishes to express his appreciation to Victor Beal, Montcalm County agricultural agent and to the cucumber growers who cooperated in the study.

[2] Hoglund, C. R. (1958). Economics of irrigating potatoes in Montcalm County, a progress report. Mich. Agr. Expt. Sta. Mimeo Report 708, 8 pp.

ARTICLE 40-90

Fig. 1. Close supervision of cucumber pickers and use of improved production practices pays off in increased returns to both growers and pickers.

ACREAGES AND PRACTICES COMPARED

A total of 150 acres, or 19 acres per farm of non-irrigated pickling cucumbers, were grown on the eight farms. The acreage of irrigated pickling cucumbers totalled 146, or 24 acres per farm, on the other seven farms (Table 1). One of these farmers produced both irrigated and non-irrigated pickles.

Four of the eight growers who did not irrigate cucumbers owned irrigation systems. The cucumbers on three of these farms were grown on land not accessible to the irrigation system. The fourth grower had planned on irrigating his pickles but found it necessary to spend full irrigation time on a large acreage of potatoes.

These four growers irrigate an average of 31 acres of potatoes and 22 acres of snap and field beans. The seven growers who irrigated cucumbers also applied water on an average of 67 acres of potatoes and 4 acres of other crops.

The farmers who were irrigating cucumbers used 20 percent more fertilizer per acre at pre-planting or planting time than did non-irrigators. They also used more than twice as much nitrogen per acre ap-

TABLE 1—Acres of various crops grown and irrigated on 15 Montcalm County farms, 1957

Item	Non-irrigated pickling cucumbers	Irrigated pickling cucumbers
Number of farms	8	7
Total acres of cucumbers grown	150	146
Acres per farm:		
Cropland	208	228
Pickling cucumbers:		
Non-irrigated	19	2
Irrigated	...	22
Potatoes:		
Non-irrigated	15	7
Irrigated	31	67
Total irrigated	53	93

plied as side-dressing or through the irrigation system. They sprayed their cucumbers more often and sprayed a higher percentage of their acreage (Table 2).

The seven growers irrigated their cucumbers an average of slightly more than two times, applying almost 3 inches of water per acre during the season. The amount of water applied per acre on different

TABLE 2—Production practices used in growing non-irrigated and irrigated pickling cucumbers, and yields, 1957

Item	Non-irrigated pickling cucumbers	Irrigated pickling cucumbers
Cover crop used, percent of acreage	94	86
Fertilizer applied per acre:		
Pre-planting or planting time, lb	330	403
N sidedressing or through irrigation, lb	18	43
Number of times sprayed	1	2.6
Percent of acreage sprayed	60	78
Irrigation:		
Average investment per farm owning	$21,693 (*a*)	$14,562
Number of times irrigated	...	2.2
Inches of water applied during season	...	2.8
Yield per acre, bushels	213	301

(*a*) Average for four farmers owning irrigation systems.

farms ranged from 2 to 4½ inches. Farmers growing large acreages of potatoes tended to give potatoes priority over cucumbers when irrigating during extended dry periods.

Yields of pickling cucumbers ranged from 159 to 317 bushels per acre for the non-irrigated acres and from 230 to 450 bushels per acre for the irrigated ones. The irrigated cucumbers yielded an average of 88 bushels more per acre. The higher yields were generally associated with larger applications of fertilizer and spray materials, and greater use of other improved production practices.

A recent Michigan study showed that irrigation could increase pickling cucumber yields by 25 percent.[3] Another study reported that farmers who had purchased irrigation systems estimated that their pickling cucumber yields had been increased by 125 bushels as a result of irrigation and the use of more fertilizer and improved practices.[4]

Timeliness in planting, spraying, and picking undoubtedly contributed to high yields. This is a factor that is difficult to measure. On some of the farms studied, it was evident that poor timing contributed to low yields. Dust or spray material was often applied too late or not often enough. Yields were reduced on other farms because pickers arrived too late in the season or there weren't enough of them for the acreage grown.

The amount of supervision a grower gives his pickers and their picking skill affect both yields and prices received per bushel. Average price received per bushel is determined by the bushels of different grades picked during the season.[5] The percentages of five different grades of pickling cucumbers sold were compared for growers doing the best and poorest jobs of supervising pickers. The growers doing the best job sold 80 percent more of grades 1 and 2 together, and 20 percent more of grade 3 than the other group (Fig. 2).

The four growers selling the highest proportion as grades 1, 2, and 3 received an average of $1.25 per bushel for their cucumbers. The other group received an average of $1.05 per bushel.

The price received per bushel for grades 1 and 2 together averaged eight times as high as for grade 5. Growers who followed poor picking practices often discarded a high proportion of cucumbers which rip-

[3] Downes, J. D. (1955). Report of the southwestern Michigan Experimental farm. Mich. Agr. Expt. Sta. Report. 13 pp.

[4] Hoglund, C. R.; E. H. Kidder and K. A. Vary (1956). Economics of irrigating in Michigan. Mich. Agr. Expt. Sta. Quart. Bul. 39(2): 208-229.

[5] Grades were as following: No. 1—under 13/16 in., No. 2—13 16 in. to 1 in., No. 3—1 in. to 1-5 16 in., No. 4—1-5 16 in. to 1-13 16 in. and No. 5—1-13 16 in. and over. (These are grades for one company).

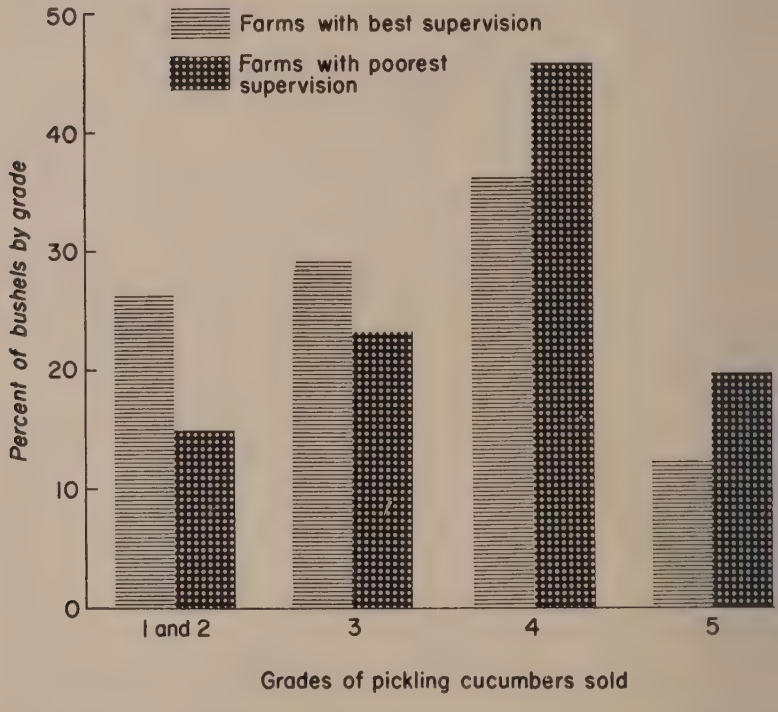

Fig. 2. Effect of good supervision and picking skill of workers on proportion of pickling cucumbers sold by different grades (average of four farms with best and four farms with poorest supervision).

ened on the vine. There was no noticeable difference in the proportion of pickling cucumbers sold by different grades between the irrigated and non-irrigated growers following good practices. The picking season was about 1 week longer for the growers who irrigated.

CHANGES IN RECEIPTS AND EXPENSES

The growers' share in the sale of pickling cucumbers averaged $65 more per acre for the irrigated than for the non-irrigated acres (Table 3). This resulted from a higher cucumber yield and a higher price received per hundredweight.

The growers who irrigated their cucumbers spent more money per acre than did the non-irrigators. They paid $8 more for fertilizer

TABLE 3—Gross receipts and specified expenses for materials and services used in producing 1 acre of non-irrigated and irrigated pickling cucumbers, Montcalm County, 1957

Item	Non-irrigated pickling cucumbers	Irrigated pickling cucumbers
	Dollars	Dollars
Gross receipts per acre (47% share)	101.52	166.85
Expenses per acre:		
Fertilizer cover crop and manure	26.28	34.43
Seed	2.12	2.10
Spray material	2.41	5.70
Labor for hoeing	10.88	12.66
Hauling pickles (*a*)	29.40	33.75
Irrigation:		
Depreciation, repairs, and interest	.....	14.40
Electricity or fuel	.....	4.23
Labor	.....	5.90
Total	71.09	113.17
Returns above specified expenses	30.43	53.68

(*a*) On farms where trucks were used in hauling pickles to grading stations, miles were converted to tractor hours. Hauling includes labor, tractor, and truck expenses.

cover crop, and manure; and more than twice as much for spray material. They also spent $6 more for labor in hoeing, and labor and power in hauling the crop to the grading station (Table 3). Variable expenses in owning and operating the irrigation equipment added nearly $25 per acre to these expenses.

Thus, the irrigators spent $42 more per acre than the non-irrigators in growing and marketing their cucumbers. The growers irrigating cucumbers, however, netted $23 more per acre above these expenses than did the non-irrigators. There were great differences among farms in the returns above expenses per acre.

IMPROVED PRACTICES IMPORTANT

The importance of timeliness in performing various operations and the use of enough fertilizer and spray material have been discussed. Average figures for yields, practices, receipts, and expenses as shown in Tables 2 and 3 do not throw much light on the economic importance of using the best combination of practices.

In order to calculate the receipts and expenses associated with average and improved practices, the farms were sorted accordingly. Yields were estimated for these two sets of practices for both non-irrigated and irrigated pickling cucumbers. These yield estimates were based on several years of data for most of the farms studied and should be readily attained.

Yields for the non-irrigated cucumbers was estimated at 200 bushels when average practices were used and 65 bushels more when improved practices were used (Table 4). The growers using the highest level of practices applied nearly 150 pounds more fertilizer on the cover crops and the cucumbers, and nearly twice as many pounds of nitrogen per acre as the growers using average practices.

For the growers irrigating cucumbers, yields per acre were estimated at 245 bushels when average practices were used and 410 bushels when greater use was made of improved practices. The irrigators following the best management practices applied, on an acre basis, 245 more pounds mixed fertilizer and more than three times as much nitrogen applied as sidedressing or through the irrigation system.

Fig. 3. Irrigation pays off best when accompanied by an adequate spray and fertilizer program.

TABLE 4—Comparison of estimated marketable yield of pickling cucumbers under average and improved production practices, Montcalm County, 1957

Item	Non-irrigated		Irrigated	
	Average practices	Improved practices(a)	Average practices	Improved practices(a)
Yield per acre, bushels	200	265	245	410
Fertilizer, lb. per acre:				
Cover crop	120	150	190	250
Plow down or planting time	285	400	340	525
N sidedressing or through irrigation	18	30	24	82
Number of times sprayed	1	6	2	6
Number of times irrigated	...	...	2	3
Inches of water applied	...	...	2.2	4.2

(a) Improved practices include those growers who are using large quantities of fertilizer and spray material, and are doing a better than average job in using improved production practices.

The higher yields also resulted from the application of more spray material and more frequent irrigation during the growing season. The growers with these higher yields applied nearly twice as many inches of irrigation water per acre during the season.

Four of the irrigators applied nitrogen at rates of 35 pounds or more per acre. Two of these applied more than 60 pounds per acre. These two growers had the highest yields of the group. They also followed a good spray program, were timely in their operations, and received an average of $1.28 per bushel of pickling cucumbers sold.

It is difficult to determine the importance of any one single practice on net income. It is entirely possible that some growers apply more fertilizer than is economically justified or fertilizer of the wrong analysis. It is also likely that many growers do not use enough fertilizer and spray material.

Ries and Carolus, during 1957, conducted field experiments at the horticultural farm at East Lansing to determine the effects of various levels of phosphorous, potassium, and nitrogen on yield of pickling cucumbers.[6] These were grown on Hillsdale sandy loam of above average productivity.

The results showed that 20 pounds of nitrogen, 80 to 160 pounds

[6]Ries, S. K., and R. L. Carolus (1958). The effect of nutrient level on growth of pickling cucumbers. Mich. Agr. Expt. Sta. Quart. Bul. 40(3): 659-668.

of phosphate, and 80 pounds of potash were adequate quantities to produce over 400 bushels to the acre. Yields were not increased by the application of nitrogen at rates above 20 pounds per acre.

These results may apply to some farms, but not at all to others because of differences in productivity and water-holding capacities of soils, previous crops grown, and other factors. Growers might experiment on their own farms to determine how much response they receive when additional quantities of fertilizer are applied. An 8-bushel increase in the yield of cucumbers would pay for about 250 pounds of 5-20-20 or ammonium nitrate fertilizer.

Whether it pays to use more fertilizer and spray material or to make greater use of improved practices depends on how much receipts and expenses are changed. Receipts and expenses in growing and marketing 20 acres of non-irrigated and irrigated pickling cucumbers were calculated for growers using average and improved practices as outlined in Table 4.

For the non-irrigators, receipts would be increased by $800 and expenses by $400, leaving a gain in net income of about $400 due to

TABLE 5—Estimated effect of using average and improved production practices and irrigation on receipts, expenses, and net income in growing 20 acres of pickling cucumbers in Montcalm County, 1957

Item	Non-irrigated		Irrigated	
	Average practices	Improved practices	Average practices	Improved practices
	Dollars	Dollars	Dollars	Dollars
Gross receipts (47% share)	2,100	2,915	2,575	4,715
Expenses:				
Cover crop	33	44	44	46
Fertilizer and manure	302	426	388	737
Spray material	48	200	64	206
Depreciation and repairs	428	428	692	784
Fuel and oil	156	216	216	273
Hired labor, hoeing	217	250	234	255
Hired labor, irrigating	...	...	95	128
Miscellaneous	230	270	236	398
Total	1,414	1,834	1,969	2,827
Returns over specified expenses.	686	1,081	606	1,888
Change in net income due to:				
Using better practices	...	395	...	1,282
Irrigating	...	...	—80	807

the use of better production practices (Table 5). This same change in production practices for the irrigators would add $2,138 to receipts and $858 to expenses. This would result in a $1,282 gain in net income due to using more fertilizer, spray material and labor, and making greater use of other improved practices.

If a cucumber grower who uses average practices now decided to invest in an irrigation system but not to make any great changes in his practices, he could end up with a lower net income (Table 5).

A non-irrigator growing 20 acres of pickling cucumbers and using improved practices could add $800 or more to net income by irrigating, and making even greater use of sound fertilizer, spray, irrigation, and other management practices.

Most pickling cucumber growers will increase net income more by first improving on their production practices and then considering the economic feasibility of investing in an irrigation system. The mere application of water will add little to yields or net income unless accompanied by adequate quantities of fertilizer and spray material and good timing in using improved cultural and harvesting practices.

A TEST OF COMBINE VARIETIES OF SUNFLOWERS IN WILDLIFE FOOD PATCHES

By LESLIE W. GYSEL and WALTER A. LEMMIEN

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SUNFLOWERS HAVE BEEN USED for many years in wildlife food patches and in gardens, primarily for bird food. Leopold et at.[1] list sunflowers as a small bird bait crop under the category of fall foods.

In the past the familiar tall sunflowers were most commonly planted. Smaller combine varieties are now available commercially and have performed well in Minnesota field tests.[2] Three of these varieties were tested in wildlife food patch plots for 4 years at the Kellogg Forest, near Battle Creek, Michigan, to determine the yield of seed and its use by wildlife. Two varieties of tall sunflowers were also tested for comparison.

The combine varieties tested are commercial varieties of *Helianthus annus* named Advance, Arrowhead, and Sunrise. These varieties varied from 2½ to 5 feet in height and had smaller leaves and heads than the common tall sunflowers (Fig. 1). The two tall varieties tested were Black Manchurian and Greystripe; these varied from 5 to 7½ feet in height.

Food patch plots were located on widely separated areas in the Kellogg Forest. The soils of three of these were classified as Fox sandy loam, one as Spinks loamy sand, and another as Hillsdale sandy loam. Four or five plots, about ½ acre in size, were planted each year. These were plowed and harrowed before planting and cultivated during the growing season to control weeds. Seeding was done with a single row mechanical planter and a band of fertilizer was applied at the time of planting.

[1]Leopold, A.; E. B. Moore and L. K. Sowls (1939). Wildlife food patches in southern Wisconsin. Jour. Wildlife Mgt. 3(1): 60-69.

[2]Robinson, R. G., and O. C. Soine (1953). Sunflowers for Minnesota? Minn. Farm and Home Sci. 10(3): 14-15.

ARTICLE 40-91

Fig. 1. The combine variety, Advance (in the foreground), is about 3 feet tall; the Greystripe is about 7 feet tall.

RESULTS

The yields of seed of the May plantings for 1954, 1955, and 1956 are given in Table 1. Of the combine varieties, Advance and Arrowhead were the largest producers, and Sunrise the smallest. Manchurian and Greystripe had larger yields than Sunrise and Arrowhead for 2 years and larger than Advance for 1 year.

TABLE 1—Average weight per acre of sunflower seeds and height of seed heads in wildlife food patches planted in May at the Kellogg Forest, Michigan, 1954 to 1956

Variety	Average height of seed heads above the ground		Average weight of seeds per acre (*a*)		
	1954	1955	1954	1955	1956
	inches			pounds	
Sunrise	43	40	891	1,050	919
Advance	42	38	1,522	1,995	1,536
Arrowhead	48	43	1,916	1,811	1,798
Manchurian	..	68	.....	1,969	2,467
Greystripe	..	81	.....	1,942	2,481

(*a*) Partially air-dried after picking.

Most of the food patch plots were planted at the same time as corn, during the middle or latter part of May. A few plots were also planted 1 month later to investigate the effects of late maturation on the utilization of the seed by birds. Five pairs of early and late-planted plots of the combine varieties were evaluated. The yields of the late plantings were 5 to 26 percent larger by weight than the early plantings.

Seeds were collected after they were fully developed and just before the birds removed a large part of the crop. The combine varieties reached this stage in 75 to 95 days after planting. Those planted in mid-June matured much faster than the May plantings. Arrowhead ripened first, Advance second, and Sunrise last. The tall Manchurian and Greystripe varieties were collected in 115 to 120 days after planting. Seeds of the June plantings did not fully develop before the first frosts stopped growth in the fall.

The high oil (24 to 30 percent), protein (15 to 21 percent), and digestible carbohydrate (20 to 25 percent) contents make sunflowers

nutritious animal food.[3] In addition, chemical analyses of sunflower seed made at the University of Illinois indicate a high content of vitamins, niacin, and thiamine.[4]

It was evident that the combine and tall varieties were highly palatable foods for small birds. By the middle of December each year, 90 to 95 percent of the crop in all of the plots was eaten. The combine varieties planted in May were picked over first, probably because they matured earlier than the tall varieties. Plots of the combine variety that were planted late were also eaten later. Seed size may also affect the rate of seed removal by birds. Robinson[5] noted selective feeding on Sunrise and Advance, which have smaller seeds than the other varieties tested.

The following bird species were observed feeding on sunflower seeds: common goldfinch, bluejay, catbird, black-capped chickadee, white-breasted nuthatch, cardinal, downy woodpecker, and red-winged blackbird. During the fall season for 2 years, flocks of at least 100 blackbirds were observed eating in the food patches. Goldfinches were also common seed eaters each fall.

Other birds observed in the sunflower food patches (but not actually observed eating the seeds) were as follows: ring-necked pheasant, bob-white, mourning dove, field sparrow, song sparrow, English sparrow, tufted titmouse, slate-colored junco, golden-crowned kinglet, and wood pewee. White-tailed deer were also observed in the food patches during the fall.

The availability of the seeds to birds is affected by the position of the seed heads. Most of the stems of the combine varieties remained upright during the time the seeds were in the head and generally for a long time after the seeds were completely removed.

The tall stems of Greystripe and Manchurian often bent over; in some plots 10 percent of the heads of these two varieties were on the ground and in others 50 to 70 percent. Generally the seed heads fell so that the seeds were on the ground covered by the large receptacles. In this position the seeds could be used mainly by mice.

A mixture of sunflowers and corn was planted in separate food patches. The growth and utilization of the sunflowers were about the same as in the sunflower plots.

[3]According to chemical analyses by personnel of the department of agricultural chemistry, Michigan State University.

[4]Robinson, R. G., and O. C. Soine (1953). Op. cit.

[5]Robinson, R. G. (1954). Department of agronomy and plant genetics, Univ. of Minn. Personal correspondence, January 5.

SUMMARY AND CONCLUSIONS

Both the combine and tall varieties of sunflowers tested produced a large amount of seed from plantings made in mid-May (at the same time as corn). Higher yields of the combine varieties resulted from plantings made in mid-June.

The high content of oil, protein, and digestible carbohydrates in the seeds makes them a nutritious animal food. Seeds of all varieties tested were highly palatable to small birds; by the middle of December 90 to 95 percent of the available crop was eaten, regardless of the size of the plot or the time of planting.

Most of the mature seeds of the combine varieties were available on upright stems. Stems of the tall varieties were often bent over so that the seeds were on the ground beneath the large receptacles, and generally not available to birds.

Both the combine and the tall varieties could be harvested and saved for use in feeding stations in the winter. The combine varieties would probably be the easiest to handle. The standing crop could be harvested by a grain combine with a few alterations or with a sunflower attachment.

The obvious value of sunflower food patches is the large amount of seed provided for small birds. It is possible, however, that these highly productive food patches also serve to reduce the competition of the large numbers of small birds with larger birds and other animals for many other foods.

CUCURBIT POWDERY MILDEW FUNGICIDE TRIALS, 1956-57

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Powdery mildew, incited by one or several strains of *Erysiphe cichoracearum* DC., has become a locally important disease of cucumbers and muskmelons in Michigan within the last 6 years. It has long been conspicuous on late or senescent squash or muskmelons, greenhouse-grown cucurbits, and fall-crop cucumbers. Now it appears in many pickling cucumber and muskmelon fields during the optimum growing period of late July and early August.

The disease presumably reduces yields even when late in onset. It tends to attack the cucurbits in Michigan early, reducing both the yield and quality of the vine crops. Because of this, a series of fungicide trials was begun in the greenhouse in 1956.

Cucumbers and several other cucurbits are injured by sulfur applications and are comparatively sensitive to fungicides in general. Preparations of dinitro (1-methyl heptyl) phenyl crotonate (Karathane, Mildex, etc.) control powdery mildew of several crops in the field and greenhouse quite satisfactorily (Beraha, et al., 1955; Crosier, et al., 1956; Godfrey, 1952; and McKeen, 1954).

Observations of field plots at East Lansing have indicated that efficient control with Karathane is best achieved if it is used as a protectant for the entire time mildew is present and applied at weekly intervals. This fungicide and several newer or experimental materials were included in the trials reported herein.

MATERIALS AND METHODS

Except where otherwise noted, the cucumber variety National Pickling[1] was used in both greenhouse and field.

In the greenhouse, an effort was made to thin plants to uniformly

[1]Seeds courtesy Ferry-Morse Seed Co.

ARTICLE 40-92

vigorous populations for the various treatments. The treatments were usually applied to single plants and were replicated four times or more. Potted material was shifted frequently on the bench in lieu of place randomization.

Sprays were applied in the greenhouse with hand sprayers and the entire plant was sprayed to the point of run-off. Sprays of griseofulvin were formulated by dissolving 95 percent material in 10 ml. of acetone, adding 1 ml. of Tween 20 wetting agent, and suspending the resultant material in 500 ml. of water.

Mildew indices were determined by rating active infections on fully developed leaves according to the arbitrary scale: 0—no mildew; 1—light infection; 2—moderate infection; 3—heavy infection with the entire upper surface covered; 4—heavy infection with death of the leaf.

In the field, a standard four-replicate randomization consisting of two-row plots 60 feet long was used. The rows sprayed were 4 feet apart and the distance between adjacent plots was 6 feet. Spray materials were applied with a John Bean "Spray Pal" power sprayer.

All data in the experiments suitable for interpretation statistically were subjected to the standard analysis of variance procedures.

EXPERIMENTAL RESULTS

Griseofulvin Soil and Spray Applications in the Greenhouse

Griseofulvin has been reported effective against several plant disease fungi including some of the powdery mildews (Brian, 1952 and Merck, 1956). Davis and Rothrock (1956) showed that it also had locally systemic effects when applied to foliage of tomato. The systemic action of this antibiotic on barley mildew was demonstrated in sand cultures by Brian (1952).

It was also reported (Jeffreys, 1952) that griseofulvin tends to be degraded in some fertile soils and its effectiveness thus reduced. Experiments were designed to test systemic effects and the effectiveness of control of mildew when griseofulvin was applied at various times in the soil and as foliage sprays.

In the first experiment griseofulvin 1 percent wettable powder was mixed with steamed potting soil at rates of 100 and 200 pounds an acre at 6, 3, 1, or 0 days before planting. The same rates of material were used for drench applications at 1, 4, or 7 days after plant-

ing. Sprays made to 200 and 500 p.p.m. from 95 percent griseofulvin were applied 10, 14, 17, or 21 days after planting.

Each treatment was used on four plants. Four controls were included for each treatment date. The test plants were inoculated by dusting them with fresh conidia of the fungus 10, 17, and 24 days after planting. The final notes of mildew incidence were taken 35 days after planting. Only the three lowest leaves of each plant were rated for mildew.

None of the treatments, soil or foliage, had controlled mildew effectively at the end of the experiment even though the overall incidence of infection was light (Table 1).

In order to determine the effect of more frequent foliar applications, lots of 44 infected plants, 4 weeks old were chosen for spraying with griseofulvin at 200 or 500 p.p.m. Four sprays were applied at weekly intervals and controls were sprayed similarly with water. One week after the fourth spray, mildew infections were rated and averaged for each treatment.

TABLE 1—Effect of griseofulvin as a soil mixture, soil drench, or foliage spray on the severity of powdery mildew of cucumber in the greenhouse

Application method	Application time in relation to planting	Disease index for indicated application rate		
		100 lb./A. or 200 p.p.m.	200 lb./A. or 500 p.p.m.	Controls
		av.(*a*)	av.	av.
Soil mixture	6 days before	1.37	.92	.67
	3 days before	.54	1.08	.79
	1 day before	.62	1.21	.75
	0 day before	.50	.79	.96
Drench	1 day after	.37	.79	.92
	4 days after	.79	.75	1.79
	7 days after	.75	1.21	1.12
Foliage spray	10 days after	1.17	1.25	1.17
	14 days after	1.12	.67	.58
	17 days after	.33	.92	1.21
	21 days after	.42	.96	.67
	All soil mixtures	.76	1.00	.78
	All drenches	.64	.92	1.28
	All sprays	.76	.95	.91
	All applications	.73	.97	.97

(*a*) Rating averages based on the scale: 0—no infection; 1—light infection; 2 moderate infection; 3—heavy infection; 4—leaf killed by infection.

Mildew was severe and partial control seemed to have been achieved by spraying. The plants sprayed with 200 p.p.m. griseofulvin had an index of 1.13; 500 p.p.m.—1.29; and the controls—2.52 (Fig. 1).

A second soil treatment trial was made using soil mixtures at 100, 200, and 300 pounds per acre of griseofulvin (1 percent) at planting time; drenches of 100, 200, and 300 pounds per acre at 5, 13, 20 or 27 days after planting; and sprays of 200, 500, or 1,000 p.p.m. applied at 16, 20, or 27 days after planting. Plants were inoculated with mildew 7 and 14 days after planting.

Mildew infection was determined on the 31st and 43rd day after planting. On the 31st day the average mildew indices ranged from .44 to 1.37 while on the 43rd day they were between 1.37 and 2.27. No consistent differences in mildew severity ascribable to treatment could be found on either occasion.

An attempt was made to confirm the apparent control obtained by repeated spraying in an earlier trial. Four groups of 16 vigorous

Fig. 1. A partial control of powdery mildew of cucumber in the greenhouse by griseofulvin sprays. Left to right: control, 500 p.p.m. griseofulvin, and 200 p.p.m. griseofulvin.

cucumber plants in the 5- to 7-leaf stage were sprayed twice at a week interval. Group 1 received griseofulvin 200 p.p.m.; Group 2, 500 p.p.m.; Group 3, 1,000 p.p.m.; and Group 4, water only.

In this experiment the griseofulvin was made from a 5 percent wettable powder formulation. Notes on mildew severity were made 1 week after the second spraying.

No clear-cut differences due to spraying or strength of material used either on sprayed or unsprayed (newly emerged) leaves could be found. Mildew lesions were forming in some cases within the areas of spray residue on top of leaves and on lower surfaces of sprayed leaves as well.

Foliage Applications — Greenhouse

Several commercial and experimental materials were compared as cucumber sprays. The materials were griseofulvin, 500 p.p.m.; Karathane (22.5 percent wettable powder, dinitro (1-methyl heptyl) phenyl crotonate), 8 oz./100 gal. rate; Chlorobenzilate 25W (25 percent wettable powder, ethyl 4, 4′-dichlorobenzilate), 1 lb./100 gal. rate; and Carbide and Carbon Chemical No. 9116 (61.6 percent wettable powder, "A nitrogen and sulfur containing heterocyclic compound"), 2 lb./100 gal. rate.

Treatments were replicated four times and applied according to the following schedule of sprays:

A. Four sprays (18, 25, 32, and 39 days after planting).
B. Three sprays (25, 32, and 39 days after planting).
C. Two sprays (32 and 39 days after planting).
D. One spray (39 days after planting).

The plants were artificially inoculated with mildew twice before starting the spraying program.

At the end of the experiment all plants had been sprayed about 1 week before rating for mildew. They varied, however, in the length of time they had been unprotected by fungicide. The results of spraying are given in Table 2. Mildew indices were averaged from the lowermost 5 mature leaves of each plant in this trial. The material Chlorobenzilate was omitted from analysis because of phytotoxicity.

An analysis of the data in Table 2 shows that all materials gave some control of the powdery mildew compared with no fungicide; and that No. 9116 was superior to the others.

TABLE 2—Comparative mildew control on cucumbers in the greenhouse with one, two, three, or four applications of three fungicide sprays

Material and concentration	Number of applications	Mildew index	Average for material
		Average (*a*)	
Griseofulvin	1	1.37	
500 p.p.m.	2	1.67	
	3	1.87	
	4	1.22	1.53
Karathane	1	1.57	
8 oz./100 gal.	2	1.42	
	3	.85	
	4	.87	1.18
No. 9116	1	1.37	
2 lb./100 gal.	2	1.12	
	3	.52	
	4	.50	.88
Control	1	1.80	
water	2	1.97	
	3	1.75	
	4	2.07	1.90
L.S.D. at the 5% level		.47	.21
L.S.D. at the 1% level		.64	.30

(*a*) Index averages based on the scale: 0 -no infection; 1—light infection; 2—moderate; 3 -heavy; 4—heavy and leaf killed.

There are more significant differences in the comparison of number of applications. In the case of No. 9116, there was a steady improvement in control with each added spray; Karathane followed a similar trend.

Griseofulvin, on the other hand, failed to demonstrate, conclusively, any added benefit obtained from four sprays over that given by one. With the exception of Chlorobenzilate, none of the materials in this experiment was phytotoxic.

Table Queen squash plants were sprayed with six fungicides in the greenhouse in order to determine their control of mildew and their phytotoxicity. Four applications were made at weekly intervals beginning with plants about 1 foot tall. The materials used were griseofulvin, 500 p.p.m.; Karathane, 8 oz./100 gal. rate; Carbide and Carbon Chemical No. 9116, 2 lb./100 gal. rate; Olin Mathieson No. 466 (50 percent wettable powder, copper dihydrazinium sulfate), 8 oz./100

gal. rate; Chlorobenzilate, 1 lb./100 gal. rate; and Thioneb 50W (50 percent wettable powder, polyethylene thiuram sulfides), 2 lb./100 gal. rate.

No. 9116 gave good control of mildew with a slight tendency to burn foliage. Karathane also gave good control without significantly harming the leaves. Thioneb, not previously tried for powdery mildew control of cucurbits, proved to be effective and seemed to be harmless to the plants. In this trial griseofulvin (from 5 percent wettable powder) gave poor control. No. 466 was not effective and Chlorobenzilate was injurious even though it seemed to have partly checked mildew.

The final greenhouse experiment in 1957 was designed to test 10 materials for effectiveness of control of powdery mildew on the cucumber. Griseofulvin was used only at 200 p.p.m., but each of the other materials was used at two different concentrations. Each treatment was replicated five times.

The plants were 16 days old, with one leaf emerged, at the time of first inoculation. Four other inoculations, at weekly intervals, were made with the last one 7 days before termination of the experiment.

Spraying was begun on the 18th day after planting and three further sprays were applied at weekly intervals. Spraying was concluded 2 weeks before termination of the experiment. Mildew indices were determined on six fully-formed leaves of each plant, and averaged (Table 3).

Analysis of the data in Table 3 confirmed observations on mildew control made during the course of spraying. Karathane, No. 9116, Thioneb 50W, Sodium Omadine (Olin Mathieson, sodium salt of 2-pyridinethione), and Dithane Z-78 (65 percent wettable powder, zineb) all appeared to reduce mildew severity significantly at both rates of application. The first three named were visibly superior to the others.

Griseofulvin, No. 466, Panogen 15 (liquid, 2.2 percent methyl mercury dicyandiamide), Geigy No. G-28810 (50 percent wettable powder, a hydroxyquinoline type compound), and Dyrene (Chemagro, 50 percent wettable powder, 2, 4, dichloro 6-10-chloroaniline triazine) were either ineffective or of doubtful practical value.

The mildew in this trial was severe because of repeated inoculation. Thus it was thought that some of the chemicals would be effective under severe field epidemic conditions.

TABLE 3—Comparative mildew control on cucumbers in the greenhouse with four applications of 10 fungicides at various concentrations

Material	Concentration	Mildew index
		av.(*a*)
Griseofulvin	200 p.p.m.	2.72
Karathane	8 oz./100 gal.	1.64
	16 oz./100 gal.	.84
No. 9116	1 lb./100 gal.	2.24
	2 lb./100 gal.	1.16
No. 466	8 oz./100 gal.	2.56
	16 oz./100 gal.	2.36
Thioneb 50W	1 lb./100 gal.	1.68
	2 lb./100 gal.	2.12
Panogen 15	2.2 p.p.m. active	2.52
	4.4 p.p.m. active	2.48
Sodium Omadine	100 p.p.m. active	2.44
	200 p.p.m. active	2.00
No. G-28810	1 lb./100 gal.	2.60
	2 lb./100 gal.	2.10
Dyrene	1½ lb./100 gal.	2.78
	3 lb./100 gal.	2.22
Dithane Z-78	1 lb./100 gal.	2.26
	2 lb./100 gal.	1.94
Control	water only	3.14
L.S.D. at the 5% level		.69
L.S.D. at the 1% level		.93

(*a*) Index averages based on the scale: 0—no infection; 1—light infection; 2—moderate; 3—heavy; 4—heavy and leaf killed.

Field Spraying

Two spraying experiments were begun in the summer of 1957 to study field control by the fungicides tested in the greenhouse or by similar materials. One of the experiments had to be abandoned because of severe mosaic infection.

The materials used in the remaining trial were Karathane, Carbide and Carbon Chemicals No. 9688 (50 percent wettable powder

"a nitropolycyclic compound"), Carbide No. 10521 (50 percent wettable powder "an arylmercapto-nitrogen containing heterocyclic compound"), and Thioneb 50W. Six sprays were applied at weekly intervals beginning July 23 and ending August 27.

Mildew first appeared in the control and border rows on August 7 at the time of the fifth picking and became more severe until the end of the experiment on September 3. Thirteen pickings were made between July 23 and September 3 with yields taken only on commercially usable "pickles". Most of these were between 2 and 4 inches in length and 10 to 100 grams in weight. None of them had begun to turn yellow (Fig. 2).

It became apparent soon after mildew had appeared that all of the spray materials used were at least partly effective controls. By August 26, the mildew severity varied greatly between treated and

Fig. 2. Size range of National Pickling cucumber fruits from 1957 field trial. Smallest fruit, 10 grams and about 2 inches long; the largest, 100 grams and 4½ inches long.

untreated plots (Table 4). Statistical analysis of these data showed clearly that useful control was furnished by all materials under the severe 1957 test conditions.

The experimental materials No. 9688 and No. 10521, as well as Thioneb are of special interest since this is a new use for them. Both No. 9688 and No. 10521 had a slight tendency to cause burn on margins of leaves after 2 or 3 sprayings. However, it was not damaging enough to reduce yield and compared well with Karathane and Thioneb in this respect. The yield totals and total number of fruits harvested per treatment for the season are summarized in Table 4.

TABLE 4—Comparative production and mildew of National Pickling cucumbers as influenced by four powdery mildew spray fungicides

Material and rate	Mildew index av.(*a*)	Yields (*b*)			Av. size fruit grams
		Lb./plot av.	Bu./acre av.	No. fruits plot av.	
Karathane—12 oz./100 gal....	1.50	241.50	292.21	2,165	50.4
No. 9688—1 lb./100 gal.....	0.25	250.50	303.10	2,197	51.7
No. 10521—1 lb./100 gal.....	0.75	235.25	284.65	2,023	52.7
Thioneb 50W—2 lb./100 gal..	0.87	227.25	274.97	2,090	49.4
Control—no spray.....	2.62	214.25	259.24	1,802	54.0
L.S.D. 5%.....	0.46				
L.S.D. 1%.....	0.65				

(*a*) Average of four replications based on 10 random observations per plot. Index averages on the scale; 0—no infection; 1—light infection; 2—moderate; 3—heavy; 4—heavy and leaf killed.
(*b*) Yields based on 13 pickings between July 23 and September 3.

An analysis of variance for yield data and number of fruits per treatment plot showed that lack of uniformity in the replications of the same treatment influenced yield enough to obscure yield differences due to treatment.

Yields of sprayed plots were larger than the control plots and it is thought that earlier onset of mildew would have caused statistically significant yield differences. The reduction of mildew severity by the spray materials was unquestionable.

DISCUSSION

The greenhouse trials showed that several new fungicides as well as Karathane, were capable of suppressing or controlling powdery mildew on cucurbits. These materials, Carbide and Carbon Chemical

No. 9116 and Naugatuck Thioneb, proved to have a low order of phytotoxicity in the greenhouse. Two other Carbide and Carbon experimental materials, No. 9688 and No. 10521, looked promising on the basis of 1 year's field trial. Thioneb was also effective in the field.

Lack of statistically significant yield differences due to treatment might have indicated lack of control were it not for the visibly good mildew control. The mildew epidemic began only after the fourth picking and natural variation between small plots of pickling cucumbers is frequently large. Because of this it is thought that the same control in commercial practice would have given noticeably increased yield. Further trials to substantiate this would be desirable.

Repeated attempts were made to find a consistent and effective systemic mildew retarding action with the antibiotic griseofulvin. A relatively low mildew-inhibiting action from sprays was displayed in some cases. This seemed a result of surface action of the residue rather than of systemic action, however.

No useful control was obtained by the various methods of soil application. It seems likely that griseofulvin was degraded too rapidly to be taken up by the plants in amounts sufficient to control cucumber mildew. It has not been demonstrated, so far as could be found, that griseofulvin is biologically very active against this strain of *Erysiphe cichoracearum*, even though it is against some other powdery mildews.

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SPARTAN ROCK—A NEW FUSARIUM WILT RESISTANT MUSKMELON

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MICHIGAN IS THE LEADING STATE in the production of late muskmelons with about 5,000 acres. A large part of the acreage is planted to strains of Honey Rock. In most areas of concentrated production, fusarium wilt *(Fusarium oxysporum f. melonis)* has become a major factor limiting production. The disease is also severe in some of the smaller, isolated areas.

At present, many growers are not using wilt resistant strains of Honey Rock because they are late and the shape is not acceptable. They aren't suitable for shipping either because of poor holding quality characterized by internal break down beginning a day or two following harvest.

No existing varieties have satisfactory fusarium wilt resistance, holding quality, and earliness. Spartan Rock was developed to satisfy these requirements.

History and Pedigree

Spartan Rock is the result of a breeding program initiated in 1943 and continued to date by various workers. The source of fusarium wilt resistance was derived from Minnesota 10-38. This variety was crossed with Howell Honey Rock (a local fusarium wilt susceptible strain). After selecting through several generations, a strain designated as Michigan 55[1] was obtained.

In 1950, a selected plant of Michigan 55 was backcrossed to Howell Honey Rock and selections were made for Honey Rock fruit type and wilt resistance. To further improve fruit type and earliness an additional backcross to Honey Rock was made in 1952. Succeeding genera-

[1]McLean, D. M. (1946). Resistance of Michigan Honey Rock No. 55 to fusarium wilt: a progress report. Mich. Agr. Expt. Sta. Quart. Bul. 29: 137-146.

ARTICLE 40-93

tions were screened for fusarium wilt resistance and selected for desirable fruit characteristics. The F_8 generation was released in 1958 as Spartan Rock.

Pedigree of Spartan Rock

Minnesota 10-38
Honey Rock (wilt susceptible)
Michigan 55-10 F_7
F_2
Honey Rock (wilt susceptible)
Honey Rock (wilt susceptible)
22-5E F_8 (Spartan Rock)

Description

As illustrated in Fig. 1, the fruit of Spartan Rock is spherical with coarse heavy netting and slight ribbing. Fruits weigh from 2 to 3 pounds depending upon number per vine and soil productivity. The flesh is fine textured, thick, and sweet. The dark green inner rind combined with the deep orange flesh color makes the cut melon very attractive.

Disease Resistance

Spartan Rock is highly resistant to fusarium wilt as has been demonstrated by extensive field tests in Michigan. It has maintained excellent growth on soils which were infested with *Fusarium* to the ex-

Fig. 1. This is the Spartan Rock muskmelon. Fruits weigh from 2 to 3 pounds, and the flesh is fine textured, thick and sweet.

tent that susceptible varieties could not be grown. Spartan Rock has no discernible resistance to powdery mildew *(Erysiphe cichoracearum)*, leaf spot *(Alternaria cucumerina)*, or mosaic.

Performance

Records on number of fruits and yield in pounds per acre are presented in Table 1. These data indicate no significant differences in total yield between Spartan Rock and the other varieties except for Homegarden which yielded significantly less.

TABLE 1—Comparative early and total yields of muskmelon varieties, East Lansing, Michigan, 1957

Variety	Yield during first 2 weeks of harvest		Total yield (seven harvests)	
	Number of fruits/acre	Weight in pounds/acre	Number of fruits/acre	Weight in pounds/acre
Spartan Rock	4,488	8,844	6,679	13,226
Honey Rock (W.R.)	1,143	4,276	3,080	10,876
Homegarden	1,143	2,323	1,671	3,300
Harvest Queen	615	2,296	1,935	7,682
Burpee Hybrid	1,935	9,266	3,432	14,572
L.S.D. .01	.....	3,247	.....	8,817

In regard to earliness, there was a definite advantage for Spartan Rock. This was apparent when it was compared with wilt resistant Honey Rock, Harvest Queen, and Homegarden. Early yields of Spartan Rock and Burpee Hybrid, as measured by weight in pounds, were essentially equal.

Productivity in terms of numbers of marketable fruit per acre was higher than any other variety. Spartan Rock produced almost twice as many fruits per acre as any of the other varieties. The large number of fruits produced by Spartan Rock is indicative of its earliness.

A recognized limitation of this variety is its small fruit size. The commercial value of Spartan Rock can be determined only after extensive trial by growers. Current breeding work is designed to combine the high quality and fusarium wilt resistance of Spartan Rock with larger fruit size.

QUALITY CONTROL IN CHERRY PROCESSING PLANTS[1]

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INTRODUCTION

The emphasis placed on quality control and improvement varies widely among plants which process and market Michigan red cherries. Many packers concentrate on quantity production at the lowest possible cost. Others attempt to build a high quality reputation in an effort to increase sales and maintain steady outlets for their products.

This study was undertaken to evaluate the problem of quality control and maintenance in red cherry processing plants in Michigan. Data were obtained from product inspection records kept by the Federal State Cooperative Inspection Service, and the Processed Fruit and Vegetable Division of the USDA, and through a survey of most of the sour cherry processing plants in the state.

FACTORS INFLUENCING QUALITY LEVELS

Raw Product: Raw product quality varies considerably between growers, plants, and days. Many factors contribute to these variations. Some plant managers undertake extensive programs designed to combat quality deterioration prior to the arrival of the fruit at the plant. These include grower education programs, quality discount or premium payment plans, and improved transportation and handling methods.

Certain defects can be partially controlled by growers through the use of better production methods. Others that are related directly

[1]Gillette, Donald G. (1956). This material included in "Quality control in sour cherry processing plants." Thesis for degree of M.S., Mich. State Univ., East Lansing.

[2]The authors wish to recognize the cooperation obtained from the Federal-State Cooperative Inspection Service, the Processed Fruit and Vegetable Division, USDA, and the managers of the cherry processing plants who provided information needed to complete the study.

ARTICLE 40-94

to weather cannot be influenced materially by production practices. Comparisons of samples of loads delivered by growers at three different plants showed that defects that can be reduced through better production and handling methods were more prevalent in loads delivered by growers with low quality.

Raw product quality is related to the amount delivered by individual growers (Table 1). In general, medium- and smaller-sized growers tend to deliver better quality than larger growers. The relationship, however, is not entirely consistent between plants.

TABLE 1—Average percent defects by grower size at five processing plants

Plant	Quantity delivered by grower (No. of lugs)						
	0-100	100-500	500-1,000	1,000-2,000	2,000-5,000	5,000-10,000	10,000 and up
1	8.0	8.2	9.0	9.5	10.0	12.5	11.3
2	8.0	6.8	6.0	6.8	7.6	8.8	...
3	8.0	7.0	7.0	7.2	8.0	8.1	...
4	7.1	6.8	6.2	6.8	7.2	...	...
5	8.5	7.5	8.6	8.8	...	...	...
Average	7.9	7.3	7.3	7.8	8.2	9.8	11.3

Programs for Improving the Quality Received: Price incentives and educational programs are used by processors to improve the quality of the raw product delivered to their plants or receiving stations. Twenty-eight out of 38 processors surveyed offered premium or discount payment plans based on Michigan revised grade standards. Discounts and premiums are usually stated as a percentage of the standard price for a pound of cherries. The various types of premium and discount plans used by these firms are shown in Table 2.

Larger firms carry on many types of educational programs ranging from direct contact to the use of mass media such as radio. Seventy percent of the firms had full-time fieldmen. Thirty-two percent held grower meetings. Over half sent out newsletters to their growers during the year. The district horticultural meetings carried on by the Cooperative Extension Service also played an important role in grower education.

Handling and Operating Practices: Methods of handling, inspection, sorting, and other elements of the processing operation have an

TABLE 2—Reported premium and discount payment plans for raw product cherries based on Michigan Revised Standards (a)

No. firms using	Description of payment plan
9	95 to 100 score—100% pay, 1% dock for each score below 95
6	1% for each score above 95, 1% dock for each score below 95
3	1½% for each score above 95, 1% dock for each score below 95
3	1% for each score above 95, 90 to 95 score—100%, 1% dock for each score below 90
2	90 to 100 score—100%, 88 to 90 score dock 3%
2	Standard price plus percent of profits above certain level
1	⅛ cent for cherries 96 or above; ¼ cent for cherries 98 to 100 score
1	1 cent per pound above standard price
1	1% for each score above 95, 88 to 95 score—100% pay

(a) Michigan Revised Standards are similar to U. S. Standards except that Michigan Revised Standards exclude undersize, undercolor, lugscald, and stems as defects.

important influence on quality. Processors interviewed in this survey varied considerably in their attitudes and operating practices in regard to quality maintenance and improvement.

Since 1952, several plants have adopted the use of water carriers to haul the fruit from large orchards or receiving stations.

When the carriers arrive at the plant, the cherries are flumed or dumped from lugs into large water tanks for storage. After the cherries are sufficiently firmed in water tanks, they are flumed from the tanks and conveyed over mechanical eliminators to inspection or sorting belts. The eliminators cull out undersized fruit and debris such as stems, leaves, and dirt.

The number of sorters per thousand pounds of cherries passing over the processing lines in an hour ranged from 1.30 to 6.67 among 38 different plants. Time studies revealed that there are great differences between sorters in their pick-out rates. The number of pounds of fruit sorted out by 155 sorters varied from 5½ pounds to over 42 pounds per sorter per hour.[3] The average pick-out rate for all sorters timed was about 20 pounds per hour.

Plants receiving poorer quality generally had higher pick-out rates. The number of sorters maintained by the plants varied little throughout the season. Adjustment for different quality levels was usually made by changing the density of flow of fruit over the belts.

Many plants have taken steps to improve the effectiveness of sort-

[3]A standardized count of 120 cherries was assumed to be equal to a pound.

cherries. To avoid these problems, one plant hired workers only after giving them a test with marbles designed to eliminate slow workers and those with defective eyesight.

Fluorescent lighting over the inspection tables was also provided by some processors to increase sorting efficiency. Experimentation in the use of colored lighting revealed that blue fluorescent lights increased sorting efficiency from 10 to 30 percent and that red fluorescent lights increased sorting efficiency about 64 percent over ordinary white light.[4]

STATISTICAL QUALITY CONTROL

It is apparent from the preceding discussion that cherry processors commit large amounts of funds to quality maintenance and improvement. The cost of fieldmen, sorting labor, quality incentive payment plans, and water tank trucks for transporting cherries are incurred largely for this purpose.

An additional technique which can be useful in many processing operations is the application of statistical quality control procedures. Where a close check on quality is desired for grading purposes or to separate lots according to quality, systematic statistical quality control can usually be adopted to advantage.

Control charts are tools that can be used to detect unusual variations in finished product quality. The control chart provides a chronological graphical comparison of actual production results with limits reflecting the ability to produce consistent quality as shown by past experience.

The first step in setting up a statistical quality control program is to determine what can be produced based on past operating performances. The result of past operations are then used to predict the results that can be expected in the future as long as operations do not change materially. The procedure for doing this is based on the fact that wherever large numbers of items are produced under a given set of conditions, there will be a set of numbers that describe characteristics around which the measurements for individual items will concentrate.

Even the most precisely standardized process must allow tolerances for some random variation from normal. The extent to which this kind of variation applies to an actual sample of measurements from a cherry

[4]Peterson, G. M., and W. M. Carleton (1951). Possibilities of using colored lights for detection of cull cherries. *Quarterly Bulletin*, Mich. Agr. Expt. Sta., Quart. Bul. 34(2): 177-178.

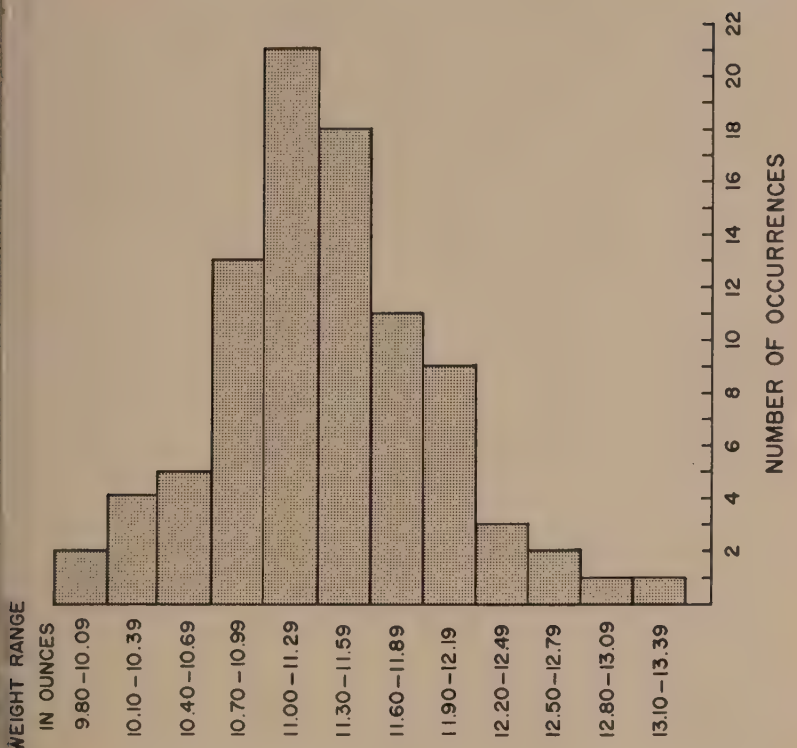

Fig. 1. Frequency of occurrence of drained weight measurements from 90 samples of 303 cans of red sour cherries.

ing labor. Sorters present a problem to the processors. Some don't remove enough defective cherries and others take out too many good processing line is shown in Fig. 1. This figure shows the number of occurrences of net drained weights of 90 samples of No. 303 cans produced on a single production line.

The position of central tendency or average for the data in Fig. 1 is 11.25 ounces. No observation occurred above 13.39 ounces or below 9.80 ounces. Most weights were within a range of 1 ounce above or below the normal value of 11.25 ounces.

Quality control charts are developed by using sample measurements of this kind to establish a position of central tendency for the product characteristic being measured. They are also used to obtain

a statistically defined area of expected variation about this central value which will result from random causes.

Once these computations have been made, a chart is drawn as in Fig. 2, with a middle line indicating the usual or average condition. This is designated as the $\overline{X}$ value. The control limits are drawn at equal distances above and below the $\overline{X}$ line. Those shown in Figs. 2 through 7 are drawn at distances from $\overline{X}$ so that about three out of 1,000 observations will fall outside of the control limits even if the average performance of the process does not change.[5]

It is not normal for the plotted value for succeeding samples to fall outside these limits or even for a series of successive points to fall either above or below the average line. If this happens, an effort should be made to discover if the average performance of the process has changed, and if so, why.

If the change is due to internal plant operations, the cause usually can be discovered and proper operating adjustment made.

In cases where the average performance has shifted because the quality of raw product has changed due to weather or maturity factors, it may no longer be reasonable to try to keep the originally-computed quality standards. The average quality line ($\overline{X}$) and the control limits should then be shifted to recognize the new general quality level. These adjustments are made in the control charts for color, defects, and character in Figs. 2 through 4. Thirty samples are averaged at a time and 10 samples are dropped and 10 added whenever a new average is computed.

Control charts may be maintained for every product characteristic that is measurable, including standard quality factors and such items as net weight, drained weight, and vacuum. The Inspection Service or plant quality control personnel can provide the necessary information for calculation of these charts. Quality factors such as color, character, defects, and total score may be obtained from all processed product inspection samples.

A separate control chart for every important quality factor can be maintained for each product and for each processing line. The observations plotted on the control charts shown in Figs. 2 through 7 are taken from actual data of a processing plant during the 1955 season.

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[5] The method of computation and distance at which control limits are set will vary for different situations. A number of references are available which can be used as a guide in determining how they should be set in any specific situation and for following through computational procedures. The most useful include T. H. Brown (1951), *Quality Control*, Harvard Bus. Rev., Vol. 29, No. 6.; E. L. Grant (1952), *Statistical Quality Control*, McGraw-Hill Book Co., New York. 563 pp.; and A. V. Feigenbaum (1951), *Quality Control*, McGraw-Hill Co., New York. 443 pp.

The point system used in scoring the quality and grade of processed cherries is described in the following table.

Score chart for canned or frozen red pitted cherries

Factors	Maximum points	Grade A fancy	Grade C standard	Grade D substandard
Color	20	17-20	14-16	0-13
Defects	40	34-40	28-33	0-27
Character	40	34-40	28-33	0-27
Total	100			

The grade of the processed product is determined by a point system of 100 points in which any of three factors—color, character, or defects—can place the sample into a lower grade. If the quality is scored down more than 15 percent (below 17 points on color, 34 points on defects and character) on any of these factors, the product will fall into grade C classification regardless of total score. If quality is scored down more than 30 percent on any of these factors the lot will fall into D grade.

Three hundred and sixty-four observations were grouped into 91 groups of four for each of the charts.

Fig. 2 is a control chart for color. Grade specification lines are drawn at 17 and 14 on the vertical axis.[6] Such things as improper soaking periods or improper cooking may cause color to fall outside of the control limits. Also the influence of seasonal conditions on

[6]Grade specifications can be incorporated into the control charts to provide information as to the probable grade that is being produced. These specifications may be represented as straight lines drawn across the control chart to distinguish between those observations that fall in A grade and those that fall in C or D grade.

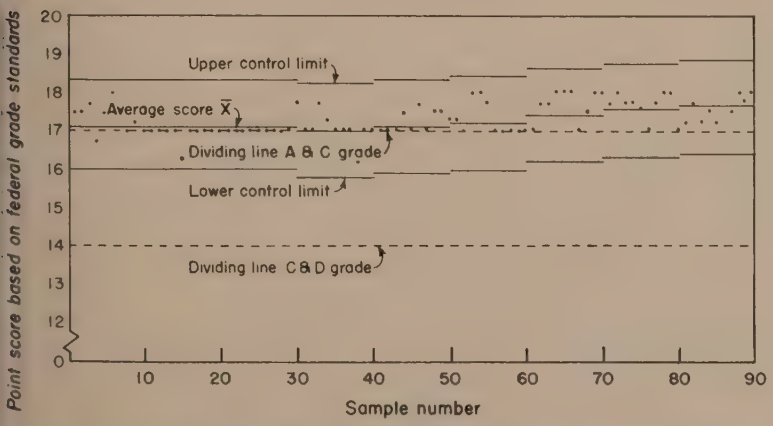

Fig. 2. Control chart for color. (See footnote 6 for explanation of scoring system used in Federal grade standards for canned or frozen red pitted cherries.)

color should be noticeable through watching the chronological plotting of this factor on a control chart.

If the latter of these factors causes the general score on color to shift, management is powerless to make any corrections. If, on the other hand, either of the two former factors cause color to deteriorate, corrective steps can and should be taken by management.

Figure 3 is a control chart for character. In this chart, grade lines are drawn horizontally from 28 and 34 to distinguish between A and C grades and between C and D grades. The variations of the observations are greater than those for color. Investigation of the cause of variation may reveal that processing equipment is not operating properly or that there is a wide variation in the quality of product being delivered by growers.

Fig. 4 is a control chart for defects. Grade lines are again drawn horizontally from 34 and 28 to indicate how the observations fall in relation to grade specifications. One observation is well outside of the lower control limit.

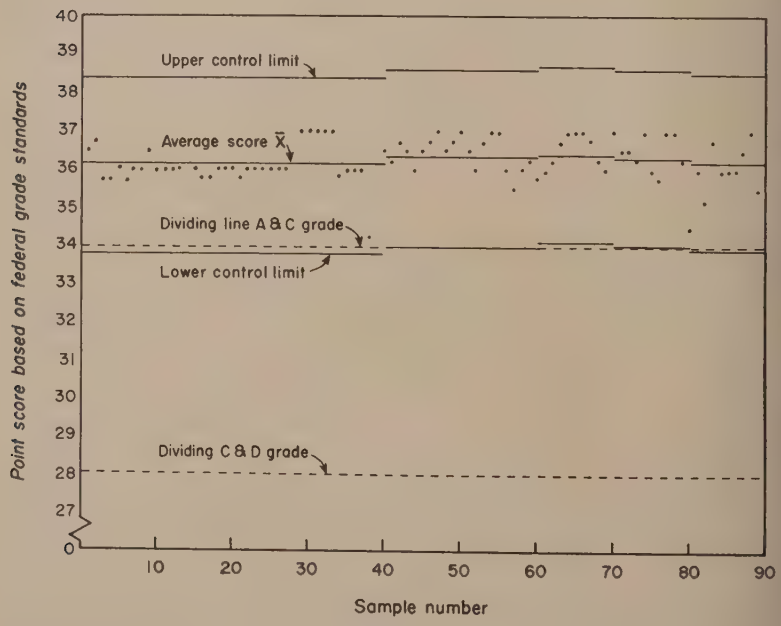

Fig. 3. Control chart for character.

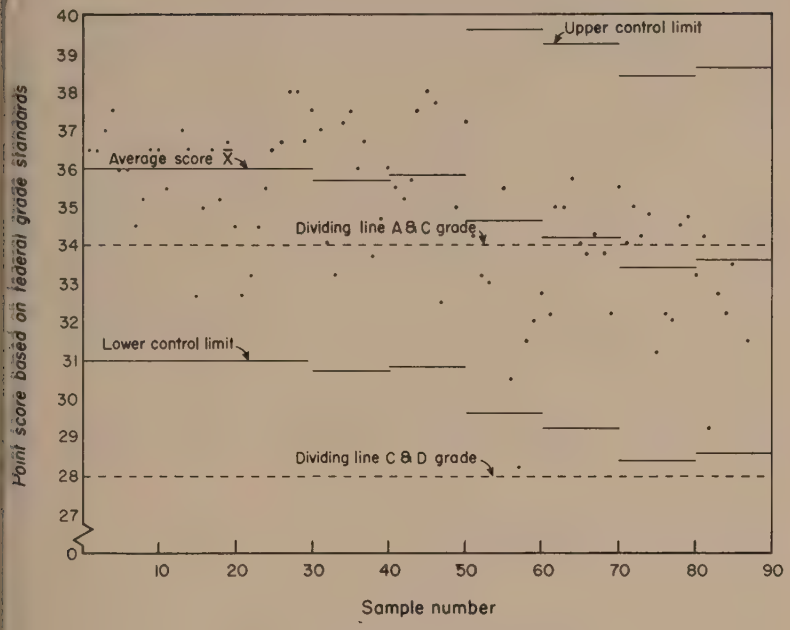

Fig. 4. Control chart for defects.

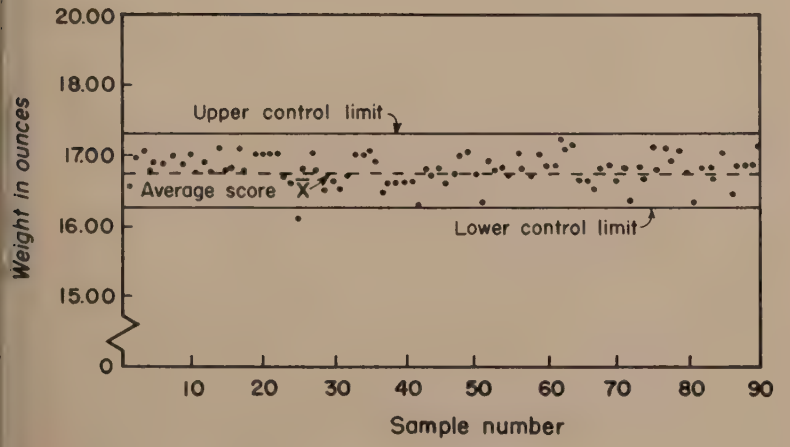

Fig. 5. Control chart, net weight (303 cans).

Excessive defects in the finished product may be caused by mechanical difficulties, poor performance of personnel, or delivery of extremely low-quality cherries by growers. If low quality is due to generally decreased raw product quality, finished product quality standards may have to be reduced.

Control charts for net weights, drained weights and vacuum on No. 303 cans are given in Figs. 5, 6, and 7. These factors are not subject to erratic adjustments due to weather or seasonal trends. Therefore, no moving adjustments are necessary and the control limits are computed as variations about a single average.

If net weights and drained weights are out of control, it may indicate that the amount of fill should be reduced or increased or that something is wrong with the filling operation. Vacuum in Fig. 7 exhibits a large amount of variation and probably could be brought under closer control by reducing the time lag between the exhaust box and the closing machine.

SAMPLING AND INSPECTION PROCEDURES

An additional aspect of plant operations which cannot be overlooked in establishing control procedures is the problem of sampling

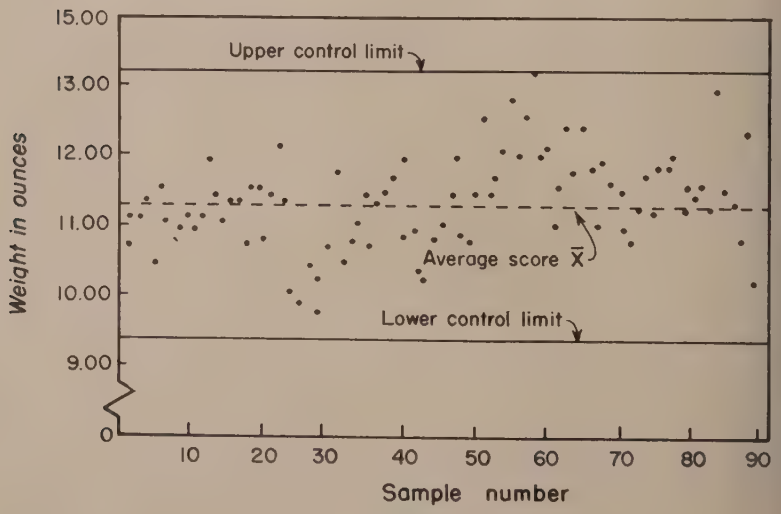

Fig. 6. Control chart, drained weight (303 cans).

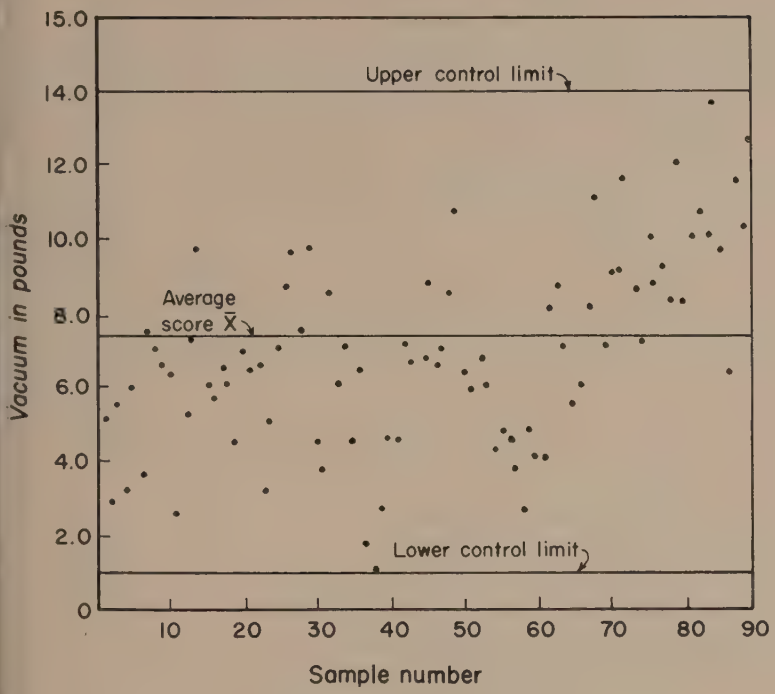

Fig. 7. Control chart, vacuum (303 cans).

and inspection of incoming raw materials. In Michigan a load of cherries cannot be accepted for processing unless it grades at least 88 score (contains at least 88 percent No. 1 cherries).

The quality of a load will be estimated correctly only if the sample is truly representative of the load. The degree to which the sample is representative will depend on the way in which the sample is drawn and on the size of the sample.

When the sample is taken prior to unloading, it is often gathered from the top two or three layers of the load. A USDA study indicates that this often results in a score which is not truly representative of the load.[7] The percentage of U. S. No. 1 quality reported by the official inspector on loads inspected prior to unloading was 5 to 9 percent higher than that found by investigators who obtained samples from

[7] Edward R. Thompson and Raymond L. Spangler (1949). *Some observations on the relationship of quality of fresh sour cherries to their processed products and effects of processing of various types of defects.* USDA, PMA, Washington, D. C.

TABLE 3—Confidence ranges for sampling raw products

Sample scores	80 percent of the time you can expect the actual quality ot your load to be between the following scores			95 percent of the time you can expect the actual quality of your load to be between the following scores			99 percent of the time you can expect the actual quality of your load to be between the following scores		
	For sample sizes of			For sample sizes of			For sample sizes of		
	120 or 1 lb.	240 or 2 lb.	360 or 3 lb.	120 or 1 lb.	240 or 2 lb.	360 or 3 lb.	120 or 1 lb.	240 or 2 lb.	360 or 3 lb.
100	98-100	99-100	99-100	97-100	98-100	99-100	96-100	98-100	98-100
99	97-100	98-100	98-100	95-100	97-100	97-100	94-100	96-100	97-100
98	96-100	96-99	97-99	94-100	94-99	96-99	92-100	94-100	95-99
97	94-99	95-98	95-98	92-99	94-99	95-99	90-99	93-99	94-99
96	92-98	94-98	94-97	90-99	93-98	93-98	88-99	91-99	92-98
95	91-97	93-97	93-96	89-98	91-97	92-97	87-99	90-98	91-97
94	90-97	91-96	92-96	88-98	90-97	91-96	86-98	89-97	90-97
93	89-96	90-95	91-95	89-97	89-96	90-95	84-98	87-97	88-96
92	87-95	89-94	90-94	85-96	87-95	88-95	83-97	86-96	87-95
91	86-94	88-93	89-93	84-95	86-95	87-94	81-96	85-95	86-95
90	85-93	87-92	87-92	82-95	85-94	95-93	80-96	83-94	85-94
89	84-93	86-92	86-91	81-94	84-93	85-92	79-95	82-94	84-93
88	83-92	85-91	85-90	80-94	83-92	84-91	78-95	81-93	82-92
87	82-91	83-90	84-89	79-93	82-91	83-90	76-94	80-92	81-91
86	80-90	82-89	83-88	77-92	80-90	82-90	74-93	79-91	80-91
85	79-89	81-88	82-88	76-91	79-89	80-89	73-92	77-91	79-90
84	78-89	80-87	81-87	75-90	78-89	79-88	72-92	76-90	78-89
83	77-88	79-86	80-86	74-90	77-88	78-87	71-91	75-89	77-88
82	76-87	78-85	79-85	73-89	76-87	77-86	69-90	74-88	75-87
81	75-86	77-85	78-84	71-88	75-86	76-85	68-90	73-88	74-86
80	74-85	76-84	77-83	70-87	73-85	75-84	67-89	71-87	73-85

all parts of the load as cherries were being dumped into the soak tanks. Inadequate sampling of this type may discourage quality incentive programs by awarding premiums or discounts to non-deserving growers.

An indication of the extent to which error can be reduced by increasing the size of the sample is shown in Table 3. This table shows the ranges within which the actual quality of a load can be expected to be 80, 95, or 99 percent of the time for different sample sizes and sample scores.

For example, if a sample of 120 cherries, randomly taken, scores 90 percent No. 1, it can be expected that, 80 percent of the time, the load will contain fruit which scores between 85 and 93. If the sample is tripled in size and scores 90, then it can be expected that, 80 percent of the time, the load will be in a quality range between 87 and 92.

As the grade of the samples approaches 88 score, the chance of making errors increases. Acceptable loads may be rejected or unacceptable loads may be accepted. The practical operating situation which faces management probably would not permit sampling in excess of 360 cherries or 3 pounds from a load. Thus the decision to accept or reject loads within a range of 2 or 3 points on either side of 88 score must be handled as a judgment policy of management. Table 3 can, however, be used to indicate the chances of being wrong in any specific situation and thereby provide the basis for establishing policy.

SUMMARY

Wide differences exist between processors in their attitudes toward quality control and maintenance programs. Some processors make extensive efforts to improve quality both before and after cherries are received at the plant. When a close check on the level and variation in quality is desired, statistical quality control procedures can probably be adopted to advantage.

The benefits from quality control and improvement increase with the increased importance of large-scale buyers and competition among sellers. Statistical quality control is a tool which will enable management to keep a closer watch on operations, thereby permitting greater standardization of product by eliminating controllable causes of quality variation. It can also provide the basis for more consistent and accurate grading of finished products.

THE SOUTHWESTERN MICHIGAN FRUIT AND VEGETABLE FARM BUSINESS, 1957

I. FARM COSTS AND RETURNS[1]

By R. G. WHEELER and E. F. LORD
DEPARTMENT OF AGRICULTURAL ECONOMICS

FRUIT AND VEGETABLE PRODUCTION represents the major source of income on an important group of farms in southwestern Michigan. During 1957, certain growers in this area participated in an exploratory phase of a study dealing with farming adjustments here and throughout the state.

The management problems of fruit and vegetable growers differ greatly from those of most other Michigan farmers. However, both groups include men who are vitally concerned about developing business units than can succeed under the changing conditions of the years ahead.

Planning for the future requires many kinds of basic, quantitative information. This article describes various aspects of the total 1957 farm business activities on 18 fruit and vegetable farms. A second article will provide more detailed data for the individual crops grown on these farms. Together, these articles are intended as a progress report which may suggest new possibilities and provide helpful data for those growers who are anxious to maintain their competitive position.

THE FARMS AND DATA

As operated in 1957, all but one of the 18 farms sold products valued at $5,000 or more, and would thus correspond to the fruit and vegetable types of Census farms in Economic Classes I - III. The

[1]B. F. French and C. R. Hoglund of the department of agricultural economics and H. J. Carew of the department of horticulture reviewed a draft of this article and offered helpful suggestions. Throughout the study, generous assistance has been received from C. F. Conrad, A. R. Earl, K. V. Washburn, J. H. Mandigo, R. F. Bittner, and the late J. P. Hoekzema, extension workers in southwestern Michigan.

ARTICLE 40-95

1950 Census reported 758 such farms in Berrien and Van Buren Counties, where this study is in progress. A 1957 count would probably have exceeded 1,000, because of increased sales per farm; nearby counties would raise the total of similar farms to 1,500 or more. Roughly half of these farms would have sold at least $10,000 worth of farm products in 1957.

A preliminary survey of Economic Class I - IV (gross sales of $2,500 or more) farms in sections of four townships near the heart of the fruit and vegetable area provided a basis for increasing the objectivity of sampling. Three-fourths of the operators proved to be rather highly specialized fruit and vegetable growers. Only a fifth had a commercial dairy enterprise, and only half of these combined dairying with fruit and vegetable production.

Nearly a third of the specialized fruit and vegetable farms were operated by men past 64 years of age who had no prospective replacement. Omitting this group, the survey sample included 102 fruit and vegetable farms in Economic Classes I - IV with an operator under 65 years of age. By total acres of horticultural crops, these 102 farms were distributed as follows:

Acres	Farms
9 to 34	48
35 to 69	34
70 or more	20

Of the 18 study farms reported here, 5 had fewer than 35 acres of fruits and vegetables, 10 had from 35 to 69 acres, and 3 had 70 or more acres. Two growers in each size group used some irrigation. Thirteen of the 18 farms sold products valued at $10,000 or more in 1957. All told, the farms with rather small crop acreages and sales below $10,000 are less than proportionally represented in the sample.

The preliminary survey revealed that few of the farms in Economic Class IV (sales of $2,500 to $4,999) were in a position to take an interest in aggressive planning for the future. Exceptions included a few operators just getting started, and some who depended a great deal on an off-farm job.

Off-farm work, especially in the winter, was also important for several of the larger growers. Thus, the final sample included six operators who had full-time off-farm jobs for 5 or more months of the year.

The cooperating growers recorded data throughout the year on various kinds of special forms chosen to fit their individual circumstances. The resulting information was summarized, transcribed, and supplemented during monthly interviews.

Minor gaps in the data were filled by estimates; major gaps caused five additional records to be excluded entirely in the present summary. From the viewpoint of statistical reliability, the limited number of farms and the variation among them must be recognized.

CROP ACREAGES AND SALES

All of the 18 cooperators grew at least five horticultural crops, and none had fewer than four to harvest in 1957. Two growers harvested as many as nine such crops, and one of the two also harvested small acreages of corn, oats, and hay. In total acreage grown, apples ranked first, followed by peaches, strawberries, and sour or red tart cherries (Table 1).

Cherries were grown on more farms than any of the other crops, but the acreage per grower was relatively small. Apples or peaches, on the other hand, accounted for a third or more of the total fruit and

TABLE 1—Crop acres per farm, by type of planting, on 18 fruit and vegetable farms in southwestern Michigan, 1957

Crop	In solid blocks		Interplanted(a)		Combined acreage(a)	Farms growing	Combined acreage per farm growing(a)
	Bearing	Non-bearing	Bearing	Non-bearing			
	Acres	Acres	Acres	Acres	Acres	Number	Acres
Apples	11.5	.2	.7	.5	12.9	11	21.0
Peaches	6.3	1.9	.7	.3	9.2	13	12.8
Strawberries	2.8	2.1	.6	..	5.5	11	9.0
Red tart cherries	2.5	1.4	..	.5	4.4	16	4.9
Tomatoes	3.4	...	.2	..	3.6	12	5.4
Pears	1.4	.6	..	.4	2.4	10	4.4
Asparagus	1.8	.5	..	..	2.3	7	5.9
Black raspberries	1.5	.4	.2	..	2.1	6	6.3
Grapes	1.9	..	..	.1	2.0	7	5.2
Melons	.9	..	.4	..	1.3	5	4.6
Sweet cherries	.7	.4	.1	..	1.2	3	6.9
Other vegetables	1.3	..	.7	..	2.0	10	3.7
Other fruits	.3	.1	.1	..	.5	6	1.4
Total horticultural crops	36.3	7.6	3.7	1.8	49.4	18	49.4
Corn, oats, hay, and acreage reserve					12.6	9	25.2
All crops					62.0	18	62.0

(a) The interplanted acreage reported for each crop is half the total area occupied by that crop and its companion crop. A few double-cropped fields are reported in the same way.

TABLE 2—Fruit and vegetable receipts per acre and per farm, 18 fruit and vegetable farms in southwestern Michigan, 1957

Crop	Bearing acres per farm	Receipts per acre	Receipts per farm
Apples	12.2	340	$4,180
Peaches	7.0	420	2,950
Strawberries	4.0	570	2,280
Tomatoes	3.6	510	1,850
Red tart cherries	2.5	580	1,460
Black raspberries	1.7	530	890
Grapes	1.9	270	520
Sweet cherries	.8	640	510
Pears	1.4	340	480
Melons	1.3	270	350
Asparagus	1.8	200	350
Other vegetables	2.0	350	690
Other fruit	.4	270	100
Total	40.6	410	16,610

vegetable acreage on 10 farms, and for somewhat more than half on three farms.

The acreage of perennial fruit exceeded the combined acreage of vegetables and strawberries on all but three farms. In most cases, however, the predominant crops were divided among several varieties, and also between bearing or non-bearing, and solid or interplanted, blocks. Thus, each grower had a relatively large number of plantings requiring some degree of individual attention.

This cropping pattern resulted largely from attempts to provide employment for hired help during various periods of the growing season. Reducing risks was another related objective.

The sales data of Table 2 also reflect diversification among a number of crops. Only five growers received as much as half of their total receipts from any one crop, although three-fourths of all sales did come from apples, peaches, strawberries, cherries, and tomatoes. Cherries ranked lower as a source of receipts than in total area, mainly because of the sizable non-bearing acreage.

INCOME AND EXPENSES

Fruit and vegetable sales accounted for 97 percent of total 1957 receipts excluding off-farm work (Table 3). Hired labor was the largest item of expense for most growers. A few, however, depended

mainly upon the labor which they and their families supplied. Hence, their hired labor cost was less than their expenses on machinery or on supplies.

The general procedure in summarizing receipts and expenses was to accept the operator's usual income-tax accounting practice. Adjustments were made in several cases where important carryovers of receipts or expenses from year to year would have distorted results. Other abnormalities of a single year's business are reduced in the second column of Table 3, which presents 2-year average data for the 1956 to 57 period.

The final section of Table 3 reports the average return for all labor, management, and capital provided by the operators and their families. This combined return in 1957 averaged $3,230 per farm, or $2,530 per operating family.

In addition, off-farm employment for the 22 operators averaged slightly more than 10 weeks in 1957. Net incomes for 1957 were

TABLE 3—Financial summary for 18 fruit and vegetable farms in southwestern Michigan, 1957 and 1956-57 average

Item	1957	1956-57 av.
RECEIPTS:		
Fruits and vegetables	$16,610	$15,580
Other	510	450
Total	$17,120	$16,030
EXPENSES:		
Hired labor	4,920	4,690
Seeds and plants	340	360
Lime and fertilizer	990	980
Spray materials	1,490	1,520
Packages	1,710	1,530
Feed and livestock expense	70	90
Other supplies	210	190
Gas and oil	800	780
Repairs and depreciation	2,210	2,260
Taxes, insurance, electricity, miscellaneous	630	640
Cash rent	150	170
Interest on debt	370	350
Total	$13,890	$13,560
NET INCOME:		
PER FARM	$3,230	$2,470
PER OPERATOR (*a*)	$2,530	$2,020

(*a*) Four of the farm businesses were partnerships; hence, there were 22 operators.

higher than for 1956, and the amount of off-farm employment was slightly larger. Three men held full-time jobs throughout both years, three more held full-time jobs for about half of each year, another was thus employed for a third of 1957, and two more held jobs for short periods in both years. Crop acreages and financial results for the seven operators with substantial off-farm employment were well distributed throughout the ranges for the 18 farms.

Total crop receipts and individual items of expense varied widely on a per-acre basis for the 1956 to 57 period. The three farms that ranked lowest in crop sales per acre had a high percentage of young or non-bearing orchards. On farms where considerable produce was packed, sales per acre were naturally higher than where crops were sold in bulk at the farm, to processors, or through fruit exchanges. In general, farms with large acreages per operator tended to have somewhat lower receipts per acre than smaller farms.

In Table 4, data for selected per-acre expenses on each of the 18 farms are listed according to the farm's descending rank for the total of these expenses. Note that the farms with the highest total expenses per acre of fruit and vegetables tended to have rather high expenses across the board, along with higher than average receipts per acre.

High expenses and high receipts per acre did not always lead to high net incomes per operator, however. In fact, the two farms ranking highest in net income per operator had rather low expenses and only moderately high receipts. Both of these growers had fairly high crop yields, but marketed most of their crops through channels requiring little or no farm expense for packing.

On the other hand, several growers did enough packing to have fairly high expenses and receipts per acre even with low crop yields. Altogether, the average net income per operator for the first nine farms in the table was $1,620, compared with $2,410 for the second nine.

The data of Table 4 are introduced mainly to emphasize the tremendous differences among individual farms. Obviously these data cannot answer the question of whether or not expenditures for more fertilizer, spray materials, labor, and packages will pay off in producing a larger and more valuable crop. The final determination must be specific for each kind of fertilizer, each spray material, each cultural practice, and for each crop, variety, or block at a particular time. Nevertheless, growers may do well to re-examine choices among

TABLE 4—Specified expenses and total crop receipts per acre of horticultural crops, and rank in net income per operator, 18 fruit and vegetable farms in southwestern Michigan, 1956-57 average (a)

Farm number	Hired labor	Packages	Fertilizer and lime	Spray	Gas and oil	Repairs and depreciation	Total specified expenses	Total crop receipts	Rank in net income per operator
1	$167H	$88H	$46H	$26	$24H	$62	$413H	$622H	5
2	136	98H	7L	52H	19	71H	383H	530H	6
3	165H	90H	18	32	23	43	371H	445	10
4	83	27	67H	29	39H	112H	357	344	14
5	137	73	30	18L	19	50	327	483H	3H
6	157H	23	31	20	15	46	292	399	8
7	122	19	35	35	20	48	279	285	16L
8	128	22	10	25	7L	51	243	230	18L
9	44	52	42H	29	16	53	236	351	11
10	100	0L	13	22	14	58	207	325	4
11	76	4	11	49H	11L	35L	186	238	12
12	40	0L	16	48H	14	64H	182	414	1H
13	35L	35	7L	35	15	23L	150	410	2H
14	42	8	16	20	24H	38	148	180L	13
15	26L	9	23	23	19	42	142	89L	17L
16	43	2L	9L	29	8L	41	132L	134L	15
17	66	15	12	10L	12	17L	132L	198	9
18	26L	18	20	4L	12	39	119L	194	7
All farms....	95	31	20	31	16	46	239	315	xx

(a) The three high and three low figures in each column have been marked with "H" and "L" respectively.

crops and among production and marketing practices that lead to intensive applications of cash inputs on a per-acre basis.

Results from the 18 farms also suggest questions about how many acres and how large a total amount of hired labor one operator can expect to manage successfully. The nine farms with the largest fruit and vegetable acreages per operator produced lower net incomes than the smaller farms. In extremely favorable years, the large businesses may prove highly profitable, but years like 1956 and 1957 fail to show much advantage for the larger farms among the group reported here.

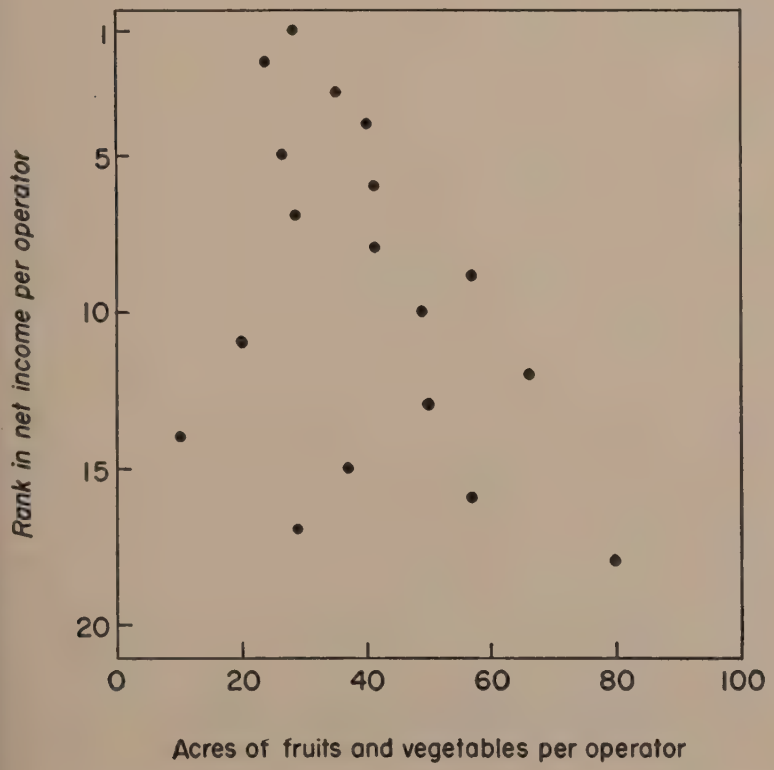

Fig. 1. Rank in net income per operator as related to acres of fruit and vegetables per operator.

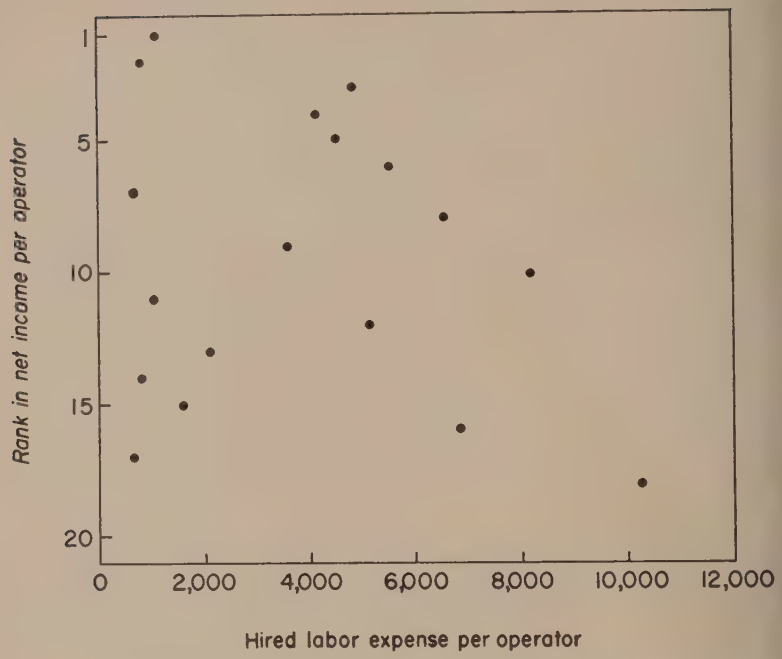

Fig. 2. Rank in net income per operator as related to hired labor expense per operator.

Figs. 1 and 2 show each farm's rank in net income as related to acreage and hired labor expense per operator. Some growers may be able to stretch limited managerial and supervisory resources over a large acreage and many workers, but there is little assurance that all growers can do so successfully.

Growers who try to expand their acreage by operating two or more tracts of land sometimes find that the distance factor alone is a major problem. This is especially true when the cropping program uses large amounts of labor which need close supervision. Peak needs for supervision can be reduced by diversifying the cropping program, but this multiplies the number of decisions to be made about fertilizing, spraying, and marketing practices.

THE SEASONAL PATTERN OF LABOR USE

More than 100 hours of labor by farm operators, members of their families, and hired hourly workers were used during 1957 for each acre of horticultural crops grown (Table 5). Half of the total was used for harvesting and marketing, mostly between June and October.

Pruning and hand thinning took about a fourth of the remaining time. The schedule for completing the pruning was rather flexible,

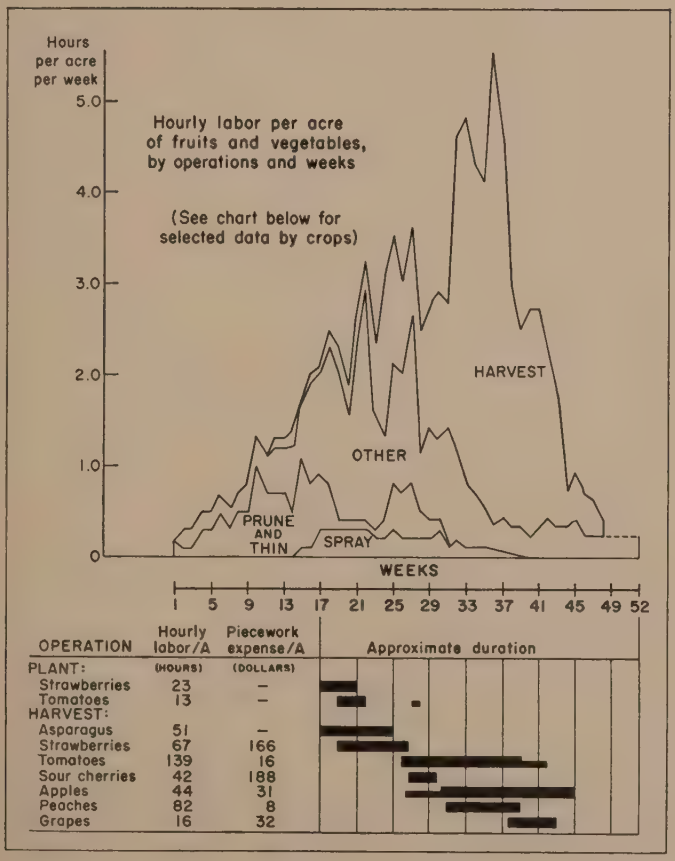

Fig. 3. Seasonal distribution of labor on 18 fruit and vegetable farms in southwestern Michigan, 1957.

TABLE 5—Seasonal distribution of hourly labor by major uses, 18 fruit and vegetable farms in southwestern Michigan, January 1 to November 30, 1957

Week	Pruning and thinning	Spraying	Soil preparation	Planting	Tractor cult.	Other pre-harvest	Harvest and market	Miscel-laneous	Total
	Man hours per acre of fruits and vegetables								
January 1- 5	.2	..	..	..	..	*	..	*	.3
6-12	.1	..	..	..	..	.1	..	.1	.3
13-19	.1	..	..	..	..	.1	..	.1	.2
20-26	.3	..	..	..	..	.1	*	.1	.6
27-Feb. 2	.3	..	..	..	..	.1	..	.1	.4
February 3- 9	.5	..	..	..	..	.1	*	.1	.7
10-16	.3	..	..	..	..	.1	*	.1	.5
17-23	.5	..	..	..	..	.1	*	.1	.8
24-Mar. 2	.5	..	..	..	..	.2	*	.1	.8
March 3- 9	1.0	..	..	..	..	.2	*	.1	1.3
10-16	.7	*	..	..	..	.2	*	.2	1.1
17-23	.7	..	..	..	..	.2	.1	.3	1.3
24-30	.7	..	*	.1	..	.1	.1	.3	1.3
31-Apr. 6	.5	*	*	.1	..	.2	.2	.4	1.3
April 7-13	1.0	.1	*	.1	*	.2	*	.3	1.8
14-20	.7	.1	.1	.3	.1	.2	.1	.4	1.9
21-27	.6	.3	.2	.2	.1	.2	.1	.4	2.0
28-May 4	.5	.3	.1	.4	.1	.6	.2	.3	2.5
May 5-11	.1	.3	.2	.3	.2	.4	.3	.5	2.2
12-18	.1	.3	.2	.5	.1	.3	.3	.4	2.2
19-25	.1	.3	.1	.7	.2	.4	.3	.5	2.4
26-June 1	.1	.3	.1	.8	.3	.9	.3	.4	3.1
June 2- 8	.1	.2	*	.2	.2	.7	.8	.9	3.1
9-15	.2	.2	*	*	.2	.4	1.8	.3	3.2
16-22	.5	.3	*	*	.2	.6	1.4	.5	3.4
23-29	.5	.2	.1	.1	.2	.6	1.0	.3	2.9
30-July 6	.6	.2	.1	*	.2	1.2	.8	.3	3.3

TABLE 5—Concluded

Week	Pruning and thinning	Spraying	Soil preparation	Planting	Tractor cult.	Other pre-harvest	Harvest and market	Miscellaneous	Total
	Man hours per acre of fruits and vegetables								
July 7-13	.3	.2	*	*	.1	.3	1.4	.2	2.6
14-20	.3	.2	*	.1	.1	.4	1.4	.4	2.9
21-27	.1	.3	*	*	.1	.4	1.6	.4	2.9
28-Aug 3	..	.1	*	*	.2	.8	1.4	.3	2.9
August 4-10	..	.2	..	*	.1	.7	3.4	.2	4.6
11-17	..	.1	*	*	.1	.5	4.0	.1	4.9
18-24	..	.1	*	*	.1	.3	3.6	.2	4.3
25-31	..	.1	*	*	*	.3	3.6	.1	4.2
September 1- 7	..	*	*	*	*	.2	5.2	.1	5.4
8-14	..	*	*	*	*	.2	4.2	.2	4.7
15-21	..	*	..	*	.1	.2	2.7	.1	3.1
22-28	..	*	*	*	*	.2	2.2	.1	2.5
29-Oct. 5	..	*	..	*	*	.1	2.5	.1	2.8
October 6-12	..	*	..	..	*	.2	2.4	.1	2.8
13-19	..	..	..	..	*	.2	1.7	.2	2.1
20-26	..	..	*	*	..	.1	1.3	.2	1.6
27-Nov. 2	..	*	..	..	..	.2	.4	.1	.8
November 3- 9	..	*	..	..	..	.2	.5	.2	1.0
10-16	..	*	..	..	..	.1	.5	.1	.8
17-23	..	..	..	..	..	.1	.4	.1	.6
24-30	..	..	..	..	..	.1	.2	.1	.5
Totals	12.1	4.6	1.2	4.0	3.0	14.2	52.2	10.9	102.2

*Less than .05.

and much of this work was done by the operators themselves when the conflict with other work was relatively slight. On the other hand, spraying took only a small amount of time but was a high priority job calling for special attention from the operator or a worker with good judgment.

"Other preharvest" work included hoeing, weeding, mulching, and similar operations directly related to the production of individual crops. Supervision, machinery repair, and buying supplies illustrate jobs included in the "miscellaneous" classification.

The weekly distribution of hourly labor used per acre of all fruits and vegetables is shown in Fig. 3. The lower chart gives data on the timing and amount of both hourly labor and piecework for selected planting and harvesting operations.

A large amount of overlap is evident in the harvesting periods for the various crops. The extent of this overlap on any one farm would be affected by the choice of varieties, planting dates, and by climatic factors in the particular year. Thus, close figuring is needed to plan

Fig. 4. Piecework expense for harvesting the strawberry crop averaged $166 per acre.

a succession of crops that can use labor evenly. Any miscalculations may lead to abandonment of some crops for lack of harvest labor.

Also note that the seasonal peaks in the top of Fig. 3 would be much higher if they included the hourly equivalent of the piecework expense for harvesting strawberries, cherries, apples, and grapes. Variations in the use of piecework labor will be covered more fully in Part II of this report.

ESTIMATING THE AVERAGE NUMBER OF ACRES PER FARM IN BARRY COUNTY, MICHIGAN BY TWO-STAGE SAMPLING

By W. D. BATEN[1]

In previous Quarterly Bulletin article (Baten 1956, 1957, and 1958) sampling by use of random numbers was explained together with techniques pertaining to stratified random sampling and optimum stratified random sampling applied to estimating the average number of acres per farm in Barry County, Michigan. In this article, sub-sampling or two-stage sampling will be explained and applied to making an estimate for the number of acres per farm in this county.

In two-stage sampling there are primary units that are chosen by use of appropriate probabilities. From these selected primary units a fixed number of elementary units are drawn at random. After a primary unit is selected it may be selected again, for the theory of this type of sampling, the primary unit is chosen with replacement. In Barry County the 16 townships are the primary units.

The probability of selecting a township is equal to the number of farms in it divided by the number of farms in the county. Townships with large numbers of farms have greater probabilities of being chosen than those with small numbers of farms.

In this county there are 4,249 farms which were numbered from 1 to 4,249 starting with the townships arranged in alphabetical order. Townships Assyria and Prairieville contain respectively 325 and 182 farms; hence, the probability of choosing the first is 325/4,249 while that of the second is 182/4,249.

It was decided to choose 4 townships at random and then draw at random 106 farms from each of them; this would make nearly a 10 percent sample. A four digit column of random numbers from a table of random numbers (Rand Corp., 1955) was used for selecting the four townships or primary units. Any four digit numbers less than 4,250 that

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ARTICLE 40-96

were encountered in going down the column of random numbers determined the townships from which to draw the second stage units, in this case, farms.

The first number less than 4,250 was 192; hence, Township Assyria was chosen because the 192nd farm was in it. The other three townships were similarly picked; they were Hope, Irving, and Woodland. It was possible to choose the same township more than once, but by this method of sampling, a township was not selected twice.

From each of these four primary units, 106 farms were drawn at random by use of random numbers. An estimate of the average number of acres per farm was obtained from the following formula by Sukhatme (1954)

(1)

$$\bar{y} = \frac{1}{n}\left[\frac{M_i}{M_o} \cdot \frac{1}{P_i} \sum_{i=1}^{n} \bar{y}_i\right],$$

where n is the number of primary units in the sample, M_i is the number of farms in primary unit i or township i, P_i is the probability of selecting township i, M_o is the number of farms in the county and $\bar{y}_i$ is the average number of acres per farm in township i in the sample.

Often M_i is not known and is estimated from a preliminary survey. In the case considered here M_i is known and $\frac{M_i}{M_o} = P_i$ and the above formula becomes

(2)

$$\bar{\bar{y}}_{s.s} = \frac{1}{n} \Sigma \bar{y}_i = \frac{1}{4}\left[72.82 + 85.98 + 82.41 + 82.37\right] = 80.89 \text{ acres},$$

which is found by taking the average of the township sample averages, and $\bar{\bar{y}}_{ss}$ signifies the average of sub-sampling. The value 80.89 acres is an unbiased estimate of the real average for the county.

The standard deviation of this estimate is according to Sukhatme (1954)

(3)

$$\sigma_{\bar{\bar{y}}_{s.s}} = \sqrt{\frac{1}{n}\left[\sum_{i=1}^{N} \frac{M_i}{M_o} \Sigma (\bar{y}_i - \bar{\bar{Y}})^2 + \sum_{i=1}^{N} \frac{M_i}{M_o}\left(\frac{1}{m_i} - \frac{1}{M_i}\right) S_i^2\right]}$$

where $\overline{Y}_i$ is the real average of the i^{th} township, $\overline{\overline{Y}}$ is the real average of the county, m_i is the number chosen from the i^{th} township. This is not a very useful formula because $\overline{Y}_i$, $\overline{\overline{Y}}$, and S_i^2 are not known; if they were known it would not be necessary to sample.

An estimate of the standard deviation of the estimate shown in equation (2) is according to Sukhatme (1954)

(4)

$$S_{\overline{y}_{s.s}} = \sqrt{\frac{1}{n-1} \frac{\Sigma (\overline{y}_i - \overline{\overline{y}})^2}{n}},$$

where $\overline{y}_i$ is the average of the sample from the i^{th} township and $\overline{\overline{y}}$ is the estimate given by (2). According to averages shown in formula (2) the standard deviation is

$$S_{\overline{y}_{s.s}} = \sqrt{(72.82-80.89)^2+(85.98-80.89)^2+(82.41-80.89)^2+(82.37-80.89)^2/12}$$

$$= 2.82 \text{ acres.}$$

Table 1 contains results of two 10 percent two-stage sampling estimates and their standard deviations.

TABLE 1—Estimates of the average number of acres per farm and the total number of acres in the county together with estimates of their standard deviations obtained from two 10 percent two-stage samples (acres)

	Estimate of the true average	Estimate of the standard deviation of the average from (4)	Estimate of the total number of acres for the county	Estimate of the standard deviation of the total
Sample 1.....	80.89	2.82	343,702	11,982
Sample 2.....	80.48	3.10	341,960	13,172
Real average..	80.18			

The values in Table 1 show that the two two-stage sampling gave excellent estimates of the real average. The .95 probability intervals for the true average to lie in for the two samples are 75.25 acres—86.53 acres and 74.28 acres—86.68 acres respectively.

Two 5 percent two-stage samples were chosen as explained for the 10 percent samples; their results are shown in Table 2.

TABLE 2—Estimates of the average number of acres per farm and estimates of the total number of acres for the county together with their standard deviations obtained from two 5 percent two-stage samples (acres)

	Estimate of the true average	Estimate of the standard deviation of the average from (4)	Estimate of the total number of acres for the county	Estimate of the standard deviation of the total
Sample 1.....	78.16	3.10	332,102	13,172
Sample 2.....	79.86	3.51	339,325	14,914

Estimates given in the above table indicate that two-stage sampling gives good results with rather small standard deviations. This method of sampling compares very well with the other methods described before.

Two 10 percent samples were taken from eight townships as explained above; in this case 53 farms were selected at random from each of these townships. Here the samples were taken from twice as many primary units as for the first two 10 percent second stage samples. The results are shown in Table 3.

The results from the second sample in this table gave a poorer estimate of the real average than the first; however, both .95 percent fiducial limits include the real mean. This was also true for the data in the first two tables; indicating that two-stage sampling led to good estimates.

By comparing Table 1 and Table 3 you can see that sampling from 8 townships gave smaller standard deviations than from four townships.

Two excellent books pertaining to sampling are by Cochran (1953); and Hansen, Hurwitz, and Madow (1953).

TABLE 3—Estimates of the average number of acres for farms and estimates of the total number of acres for the county together with their standard deviations obtained from two 10 percent two-stage samples from eight townships (acres)

	Estimate of the true average	Estimate of the standard deviation ot the average	Estimate of the total number of acres for the county	Estimate of the standard deviation of the total
Sample 1.....	79.63	1.18	338,348	5,014
Sample 2.....	76.76	2.76	326,153	11,727

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INTERRELATIONSHIPS OF FURAZOLIDONE AND OTHER FEED ADDITIVES ON THE GROWTH OF POULTRY

By C. W. POPE and PHILIP J. SCHAIBLE

DEPARTMENT OF POULTRY HUSBANDRY

THIS STUDY WAS CONDUCTED to determine the effect of feeding low-levels of furazolidone, penicillin, arsanilic acid, 3-nitro 4-hydroxy phenylarsonic acid and their combinations upon the growth rate of broilers and feed efficiency. It is a continuation of the research of Libby and Schaible.[1]

PROCEDURE

Two experiments were conducted, involving a total of 2,350 cockerels and 750 pullets. Birds were grown on shavings in floor pens in a closed-type brooder house having a concrete floor heated by circulating warm water in imbedded pipes. Heat lamps were used as an auxiliary source of heat for the first 3 weeks. The pens allowed 1 square foot of floor space per bird.

The basal diets are presented in Table 1. Ration 55B-1 was used for the first 6 weeks; ration 55F-1 thereafter. The experimental design is presented in Table 2.

In the first experiment, day-old White Rock male chicks of the Arbor Acre strain were used in lots of 100 chicks each. Replications were made at different times and the data pooled. Feed consumption and growth data were collected every other week through 8 weeks of age.

In the second experiment, pens consisted of 25 male and 25 female White Rock chicks of the Cobb strain. Each ration was fed to tripli-

[1]Libby, D. A., and P. J. Schaible (1955). The effect of low levels of furazolidone in poultry feeds upon early growth of chickens. Mich. Agr. Expt. Sta. Quart. Bul. 38: 241-251. Also Schaible, P. J. (1956). Effect of low levels of furazolidone in poultry feed. Proc. of 1st Nat. Symposium on Nitrofurans in Agr., Mich. State Univ.: 51-55.

ARTICLE 40-97

cate lots and contained a coccidiostat. Birds were weighed and feed intake was obtained every third week through 9 weeks.

The data for the overall periods are given in Table 2 since interim data followed their general trends. The least squares method of analysis[2] was used and treatment mean values were compared employing the test developed by Schaffe.[3]

RESULTS

In these experiments (Table 2) no significant growth improvement was obtained when furazolidone, penicillin, or arsanilic acid was added singly (Lots 2, 3, and 8). However, significant growth responses

[2]Snedecor, G. W. (1950). *Statistical Methods.* Iowa State College Press, Ames, 4th Ed. 485 pp.
[3]Scheffe, H. (1953). A method for judging all contrasts in the analysis of variance. Biometrika 40:87-104.

TABLE 1—Composition of rations (½-ton mix)

Ingredient	Ration number	
	55B-1	55F-1
	lb.	lb.
Yellow corn, ground	472.6	547.7
Wheat, ground	37.5	37.5
Oats, pulverized	37.5	37.5
Alfalfa leaf meal, dehydrated	25.0	25.0
Soybean oil meal, 44% protein	250.0	150.0
Corn gluten meal	....	25.0
Animal fat	40.0	40.0
Fish meal, red	50.0	25.0
Meat scraps, 50% protein	....	25.0
Whey, dried	25.0	25.0
Brewers' yeast, dried	25.0	25.0
Dicalcium phosphate	10.0	10.0
Limestone, ground	15.0	15.0
Salt (iodized)	2.5	2.5
Choline chloride, 25% dry mix	2.5	2.5
Multi-vitamin mixture (*a*)	2.5	2.5
Vigofac (*b*)	2.5	2.5
Methionine	1.0	1.0
Vitamin B_{12} supplement, 6 mg/lb	.25	.25
Vitamin E supplement (c)	.125	.125
Manganese sulfate, feeding grade	.25	.25
DPPD	.2	.2
Nicarbazin mixture "25%" (*d*)	.5	.5

(*a*) Each pound contains 2 grams riboflavin, 4 grams calcium pantothenate, 9 grams niacin, and 10 grams choline chloride.
(*b*) Chas. Pfizer and Co.
(*c*) 20,000 IU vitamin E per pound.
(*d*) Used only in Trial 2.

TABLE 2—Live weights and feed efficiencies (Experiment 1—8 weeks of age; Experiment 2—9 weeks of age)

Lots	Additives(a)	Live weight in pounds				Feed efficiency		Percent mortality	
		Experiment 1	Experiment 2						
		Males	Males	Females	Sex corrected	Experiment 1 males	Experiment 2 both sexes	Experiment 1 males	Experiment 2 both sexes
1	None.....	2.66	3.58	2.86	3.22	2.39	2.69	1.0	4.0
2	F.....	2.69	3.53*	2.82*	3.18*	2.31	2.70	2.0	2.0
3	P.....	2.68	3.55	2.81*	3.18*	2.32	2.60	2.5	2.6
4	F+P.....	2.73**	3.62*	2.93*	3.27*	2.26	2.57	.5	.3
5	N.....	....	3.74**	2.96**	3.37**	....	2.53	...	2.0
6	P+N.....	2.77**	3.62*	2.90*	3.26*	2.24	2.54	2.0	1.3
7	F+P+N....	2.84**	3.63*	2.95**	3.31*	2.21	2.48	1.0	5.3
8	A.....	....	3.59	2.84	3.21	....	2.49	...	4.0
9	P+A.....	....	3.66*	2.83	3.24	....	2.51	...	4.0
10	F+P+A....	....	3.66*	2.87	3.27*	....	2.46	...	6.6
Sx	.....	.011	.014	.014	.012				

*Significantly different at 5 percent level from Lot 1.
**Significantly different at 1 percent level from Lot 1.
(a) Per ton of feed: F—10 gm. furazolidone; P—2 gm. penicillin; N—45 gm. "3-nitro"; A—90 gm. arsanilic acid.

were obtained with combinations of furazolidone and penicillin (Lot 4); furazolidone, penicillin, and "3-nitro" (Lot 7); as well as penicillin and "3-nitro" (Lot 6).

Highly significant growth responses for both sexes were obtained with "3-nitro". The combination of furazolidone, penicillin, and "3-nitro" (Lot 7) resulted in significant growth responses for females only.

Combinations of penicillin and arsanilic acid (Lot 9); and furazolidone, penicillin and arsanilic acid (Lot 10) resulted in significant growth responses only for males.

In Experiment 2, weights of Lots 2 and 3 were, in most cases, significantly less than on the control ration; in Experiment 1 they were not. When the weights of males in both experiments were analyzed, there was no significant reduction in weights.

It has been generally observed that response to antibiotics and other growth stimulants is related to level of contamination. Therefore, possibly greater responses might have resulted if some used litter from older birds had been incorporated in the feed.

In all trials, feed efficiencies were satisfactory and, in all but one instance, better than the controls. The differences between the treatments and the control, however, were not significant because only one measure of feed intake was made per replicate.

SUMMARY

In two different experiments, furazolidone, penicillin, arsanilic acid, and 3-nitro 4-hydroxy phenylarsonic acid were fed at low levels, alone and in combination, in broiler and broiler-finisher rations to broiler-strain chicks.

Furazolidone, penicillin, or arsanilic acid fed singly did not always produce a growth response. Furazolidone, in combination with penicillin or with penicillin and "3-nitro", gave significant growth responses as did penicillin and "3-nitro".

Highly significant responses were obtained with "3-nitro" for both sexes; the combination of furazolidone, penicillin and "3-nitro" was significant for females only. A combination of arsanilic acid and penicillin, with and without furazolidone, increased growth rate in the males, but not in the females.

Feed efficiency was improved quite generally with these chemicals, alone and in combination, over that of the basal rations, but the differences were not statistically significant.

THE MINERAL CONTENT OF CORN GROWN ON A KALAMAZOO SANDY LOAM SOIL AS AFFECTED BY THE USE OF COMMERCIAL FERTILIZER

By E. R. DOWDY, L. S. ROBERTSON, and W. B. SUNDQUIST[1]

NUMEROUS INVESTIGATIONS have been made on the influence of commercial fertilizer on the mineral content of corn. The elemental composition is considered an index of feed value as well as a means of studying the nutrition of plants.

The purpose of this project was to determine the effect of widely varying combinations of nitrogen, phosphoric acid, and potash fertilizers on the yield of grain and on the nitrogen, phosphorus, potassium, magnesium, calcium, and sodium contents of both corn grain and leaves.

REVIEW OF LITERATURE

Stubblefield and Deturk (1940) observed that seeds had a more constant chemical composition than leaves. They felt that the composition of the leaf can be expected to vary since it represents the minerals left over after seeds have formed. They also noted that weather conditions exert a profound influence upon the yield and chemical composition of corn grown on a given plot from year to year.

Vandecaveye (1940), in a summarization of the literature prior to 1940, reported that only late or very large applications of nitrogen effected the composition of the grain. Complete fertilizers gave irregular results, although in a substantial number of cases, the fertilizer treatments produced grain with an increased nitrogen and phosphorus content.

[1]A former graduate student in soil science, Mich. State Univ.; assistant professor of soil science, Mich. State Univ.; and agricultural economist, FERD, Agricultural Research Service, U. S. D. A., respectively.

ARTICLE 40-98

Kling (1937) found that complete fertilizers had no significant effect on the nitrogen, phosphorus, or potassium content of the grain, but increasing amounts of nitrogen produced green plants with higher nitrogen contents.

Weeks, et al. (1940), from a field experiment, reported that fertilizer treatments affected the amount of calcium, potassium, phosphorus, and magnesium, and to a lesser extent, the nitrogen content of the grain.

Munsell and Brown (1949) reported that the phosphorus and calcium contents of the leaf and grain were not increased with increasing rates of fertilization. From their field studies, they noticed a decrease in the calcium to potassium ratio and the magnesium to potassium ratio with each increment of applied potassium fertilizer.

Beeson (1941) analyzed corn grain grown on different New York soils for the mineral composition of the grain and found some widely varying data. The sodium content ranged from .001 to .125 percent with an average of 0.48 percent. The potassium content ranged from .22 to .92 percent with an average of .40 percent. The calcium content varied from .006 to .045 percent with an average of .01 percent. The magnesium content varied from .09 to .27 percent with an average of .16 percent. The phosphorus content ranged from .23 to .80 percent with an average of .43 percent.

METHODS

This work was a part of a nutrient level and balance study. Field plots were established in Kalamazoo County on a Kalamazoo sandy loam soil in 1955. Sixty-two plots were selected to be sampled for chemical analyses. A minimum of nine plots was used to represent a specific level of a given fertilizer nutrient. The rates and combinations of fertilizer nutrients are shown in Table 1.

The carriers of the three major plant nutrients were ammonium nitrate, 33½ percent nitrogen; superphosphate, 45 percent P_2O_5; and murate of potash, 60 percent K_2O. The nitrogen and potash fertilizers were applied at rates of 0 to 240 pounds per acre. Applied P_2O_5 ranged between 0 and 480 pounds per acre.

The nitrogen and potash fertilizers were broadcast prior to plowing. If a plot was to receive more than 40 pounds of P_2O_5 per acre, the amount over 40 pounds was broadcast prior to plowing. All of the

TABLE 1—The effect of various rates and combinations of nitrogen, phosphoric acid, and potash fertilizers on the yield and chemical composition of corn grain

Fertilizer applied (pounds per acre)			Yield shelled corn bushels /acre	Chemical analysis of grain Percent					
N	P_2O_5	K_2O		N	P	K	Mg	Ca	Na
0	0	0	51.1	1.52	.23	.35	.19	.008	.007
0	40	20	55.4	1.15	.18	.30	.19	.009	.009
0	160	80	41.5	1.30	.17	.31	.18	.005	.008
0	480	240	53.6	1.57	.19	.33	.18	.011	.009
20	0	20	50.2	1.43	.17	.37	.15	.009	.010
20	40	0	58.8	1.53	.23	.37	.19	.010	.009
20	40	20	76.1	1.81	.19	.30	.20	.006	.010
20	40	240	55.4	1.51	.23	.35	.17	.010	.011
20	80	160	58.8	1.73	.22	.35	.19	.008	.007
20	160	80	55.4	1.56	.19	.30	.17	.008	.007
20	160	240	48.4	1.71	.17	.25	.19	.004	.009
20	320	40	57.1	1.68	.17	.33	.16	.002	.007
20	480	20	51.9	1.67	.23	.25	.18	.005	.007
20	480	80	51.9	1.28	.28	.33	.19	.008	.008
20	480	240	58.8	1.62	.26	.36	.20	.009	.011
40	40	40	69.2	1.77	.19	.21	.15	.006	.008
40	40	160	67.5	1.65	.25	.30	.15	.006	.006
40	80	20	57.1	1.87	.24	.30	.13	.007	.007
40	80	40	62.3	1.71	.21	.30	.15	.007	.008
40	80	80	51.9	1.46	.27	.36	.25	.005	.010
40	80	240	58.8	1.27	.26	.29	.10	.006	.009
40	320	20	43.3	1.46	.23	.30	.15	.006	.010
40	320	80	55.4	1.59	.26	.30	.20	.006	.011
40	320	240	55.4	1.73	.23	.36	.28	.009	.011
80	0	80	55.4	1.62	.25	.35	.18	.010	.010
80	40	20	45.0	1.44	.16	.35	.28	.009	.008
80	40	80	50.6	1.38	.17	.40	.23	.009	.011
80	40	240	46.7	1.44	.18	.30	.20	.006	.010
80	80	40	50.2	1.45	.18	.33	.20	.013	.008
80	80	160	51.9	1.60	.13	.22	.23	.002	.007
80	160	0	57.1	1.50	.18	.39	.15	.008	.008
80	160	20	46.7	1.21	.16	.38	.33	.007	.009
80	160	80	57.1	1.38	.20	.41	.23	.006	.007
80	160	240	55.4	1.74	.19	.36	.23	.010	.007
80	320	40	45.0	1.41	.22	.39	.20	.007	.008
80	320	160	58.8	1.72	.20	.38	.10	.005	.008
80	480	20	57.1	1.64	.17	.30	.13	.006	.010
160	40	40	57.1	1.75	.18	.34	.08	.008	.010
160	40	160	69.2	1.78	.23	.41	.25	.008	.006
160	80	40	72.7	1.59	.20	.37	.15	.007	.008
160	160	40	43.3	1.49	.19	.29	.13	.006	.008
160	320	20	62.3	1.55	.17	.27	.05	.006	.010
160	320	160	48.4	1.39	.22	.30	.28	.002	.006
160	320	240	60.6	1.62	.20	.27	.13	.007	.011
160	480	40	43.3	1.72	.23	.29	.20	.006	.009

TABLE 1—Concluded

Fertilizer applied (pounds per acre)			Yield shelled corn bushels /acre	Chemical analysis of grain Percent					
N	P_2O_5	K_2O		N	P	K	Mg	Ca	Na
160	480	160	48.4	1.18	.22	.30	.13	.007	.007
240	0	240	60.6	1.56	.24	.27	.18	.011	.009
240	40	80	57.1	1.73	.19	.22	.10	.006	.008
240	80	160	41.5	1.42	.28	.41	.33	.009	.008
240	160	20	48.4	1.34	.19	.27	.20	.009	.007
240	160	80	74.4	1.72	.19	.27	.08	.007	.011
240	160	240	76.2	1.85	.21	.29	.10	.009	.009
240	480	0	74.4	1.64	.19	.22	.18	.009	.007
240	480	20	39.8	1.56	.19	.29	.13	.009	.008
240	480	80	48.4	1.28	.17	.30	.23	.011	.010
240	480	160	69.2	1.65	.16	.25	.28	.009	.008
240	480	240	48.4	1.50	.20	.37	.05	.009	.008

nitrogen and potash and the amount of P_2O_5 over 40 pounds per acre were plowed down.

The 40 pounds of P_2O_5 were used as a starter fertilizer on all plots except the "no P_2O_5" plots. One-half of this was placed in a band 2 inches to the side and 2 inches below the seed. The other half was placed in a band 2 inches to the side and 6 inches below the seed. The plots had recently been limed so that the pH ranged between 5.9 and 6.3.

Leaf samples consisting of 10 basil ear leaves per plot were taken on August 13, 1956. Pollination was complete and seeds had started to form at sampling time. The samples were ground and stored in cardboard containers until the analyses were made.

The grain samples were obtained at harvest time. Twenty ears were taken from each plot. They were dried and shelled. Sub-samples were taken from the shelled corn. They were ground and stored in glass bottles until analyses were made.

The plant tissue samples were ashed with certain modifications of the nitric acid-perchloric acid method described by Piper (1944).

The nitrogen content was determined by the Kjeldahl procedure with certain modifications of the method described by Pierce and Haenisch (1948). The phosphorus content was determined by the ammonium-molybdate method. The potassium content was determined on the Perkin-Elmer flame photometer, Model 52-A, as described by Toth, et al. (1948).

Drosdoff and Nearpass (1948) method was used to determine the magnesium content. A Beckman spectrophotometer, Model DU, with a flame attachment was used to determine the calcium and sodium contents.

RESULTS

The data in Table 1 do not reflect large differences in chemical composition of grain caused by various fertilizer treatments. Nitrogen fertilizers, in a few cases, seemed to increase the nitrogen content of the grain. Apparently, the crop was able to obtain enough nitrogen from the soil to produce grain with a relatively constant nitrogen content. In this experiment, corn followed a mixed clover-alfalfa hay.

The phosphorus content of the grain was not significantly affected by the various rates of phosphorus fertilizer. There was no apparent correlation between the amount of potash fertilizer used and the potassium content of the grain.

Correlation coefficients between yield, nitrogen, phosphorus, potassium, magnesium, calcium, and sodium contents of corn grain produced in this experiment are shown in Table 2. The highest yields were associated with grain that had a high nitrogen and a low magnesium content. No other statistically significant correlations involving yield were noted.

TABLE 2—Correlation coefficients between yield, nitrogen, phosphorus, potassium, magnesium, calcium, and sodium contents of corn grain

	N	P	K	Mg	Ca	Na	Yield
N	1.000**	.036	−.160	−.254*	−.100	.010	.510**
P	.036	1.000**	.292*	.058	.133	−.038	−.032
K	−.160	.292*	1.000**	.282*	.309**	.004	−.205
Mg	−.254*	.058	.282*	1.000**	.071	−.118	−.259*
Ca	−.100	.133	.309**	.071	1.000**	.100	−.045
Na	.010	.038	.004	−.118	.100	1.000**	.119

*Significant at the 5 percent level of probability.
**Significant at the 1 percent level of probability.

Several relationships between various elements in the grain were evident. High nitrogen levels were closely related to low magnesium levels. High magnesium, calcium, and phosphorus levels were associated with high potassium levels.

Leaf tissue varied more in chemical composition as an effect of fertilizer than did grain. The use of extra increments of nitrogen fertilizer increased the leaf tissue nitrogen content. Increasing amounts of phosphoric acid also increased the phosphorus content of the leaves and increasing increments of potash fertilizer did the same for potassium levels.

Correlation coefficients between yield, nitrogen, potassium, phosphorus, magnesium, calcium, and sodium contents of the corn leaves are shown in Table 4. High yields were associated with high nitrogen and low sodium contents. Low sodium or potassium levels were correlated with high nitrogen levels. High phosphorus was associated

TABLE 3—The effect of various rates and combinations of nitrogen, phosphoric acid, and potash fertilizers on yield and chemical composition of corn leaf

Fertilizer treatment (pounds per acre)			Yield shelled corn bushels /acre	Chemical analysis of leaf Percent					
N	P_2O_5	K_2O		N	P	K	Mg	Ca	Na
0	0	0	51.1	2.35	.15	1.51	.45	.87	.010
0	40	20	55.4	2.13	.13	1.69	.45	1.01	.010
0	160	80	41.5	1.83	.11	2.25	.33	.81	.014
0	480	240	53.6	2.12	.14	2.30	.28	.66	.009
20	0	20	50.2	2.55	.13	1.65	.41	.75	.010
20	40	0	58.8	2.78	.13	1.20	.49	.86	.010
20	40	20	76.1	2.80	.18	1.78	.40	.66	.007
20	40	240	55.4	2.36	.14	2.43	.29	.69	.010
20	80	160	58.8	2.41	.12	2.30	.28	.73	.010
20	160	80	55.4	2.34	.17	2.13	.34	.62	.010
20	160	240	48.4	2.14	.16	2.43	.29	.75	.007
20	320	40	57.1	2.30	.18	1.46	.56	.94	.010
20	480	20	51.9	2.66	.22	1.02	.60	.91	.009
20	480	80	51.9	2.41	.25	2.00	.26	.71	.011
20	480	240	58.8	2.14	.24	2.26	.35	.68	.010
40	40	40	69.2	2.53	.18	1.73	.34	.84	.010
40	40	160	67.5	2.52	.19	2.38	.29	.63	.008
40	80	20	57.1	2.38	.17	1.27	.61	.93	.011
40	80	40	62.3	2.56	.19	1.69	.43	.93	.008
40	80	80	51.9	2.52	.18	1.62	.30	.78	.009
40	80	240	58.8	2.81	.20	1.24	.28	.60	.011
40	320	20	43.3	2.21	.23	2.43	.35	.80	.008
40	320	80	55.4	2.25	.23	1.65	.43	.73	.007
40	320	240	55.4	2.11	.20	1.90	.28	.67	.008
80	0	80	55.4	2.96	.23	1.78	.43	.80	.010
80	40	20	45.0	2.64	.23	1.41	.53	.89	.009
80	40	80	50.6	2.67	.24	1.75	.39	.93	.009
80	40	240	46.7	2.39	.23	1.88	.34	.73	.009

TABLE 3—Concluded

Fertilizer treatment (pounds per acre)			Yield shelled corn bushels /acre	Chemical analysis of leaf Percent					
N	P_2O_5	K_2O		N	P	K	Mg	Ca	Na
80	80	40	50.2	2.65	.20	1.75	.30	.73	.007
80	80	160	51.9	2.83	.22	2.14	.25	.62	.007
80	160	0	57.1	2.85	.21	1.08	.83	1.28	.009
80	160	20	46.7	2.59	.24	1.65	.41	.84	.010
80	160	80	57.1	2.34	.25	1.88	.39	.71	.010
80	160	240	55.4	2.62	.20	2.13	.23	.57	.006
80	320	40	45.0	2.45	.26	1.49	.43	.80	.009
80	320	160	58.8	2.38	.24	1.95	.33	.69	.006
80	480	20	57.1	2.52	.36	.99	.73	1.06	.011
160	40	40	57.1	2.60	.19	1.58	.38	.89	.006
160	40	160	69.2	2.94	.19	1.84	.25	.71	.006
160	80	40	72.7	3.00	.13	1.65	.43	.96	.014
160	160	40	43.3	2.44	.11	1.19	.56	1.25	.011
160	320	20	62.3	2.78	.19	1.20	.61	1.08	.006
160	320	160	48.4	2.91	.13	2.10	.31	.75	.011
160	320	240	60.6	2.76	.15	2.08	.35	.69	.006
160	480	40	43.3	2.91	.24	1.19	.60	.90	.007
160	480	160	48.4	2.80	.19	2.16	.28	.80	.007
240	0	240	60.6	3.01	.17	2.41	.25	.47	.007
240	40	80	57.1	2.87	.14	2.16	.36	.69	.005
240	80	160	41.5	2.91	.16	2.13	.28	.86	.006
240	160	20	48.4	2.39	.14	1.69	.40	.86	.006
240	160	80	74.4	2.95	.17	1.45	.51	.94	.005
240	160	240	76.2	3.15	.17	1.73	.25	.57	.004
240	480	0	74.4	2.71	.22	1.62	.53	.89	.005
240	480	20	39.8	2.54	.22	1.23	.58	1.02	.006
240	480	80	48.4	2.03	.17	2.43	.25	.80	.004
240	480	160	69.2	2.87	.22	1.89	.40	.86	.007
240	480	240	48.4	2.80	.23	1.78	.36	.86	.007

TABLE 4—Correlation coefficients between yield, nitrogen, phosphorus, potassium, magnesium, calcium, and sodium contents of corn leaf

	N	P	K	Mg	Ca	Na	Yield
N	1.000**	.108	−.219*	.082	−.017	−.337**	.415**
P	.108	1.000**	−.203	.231*	.034	−.133	−.040
K	−.219*	−.203	1.000**	−.806**	−.667**	−.172	−.018
Mg	.082	.231*	−.806**	1.000**	.817**	.190	−.031
Ca	−.017	.034	−.667**	.817**	1.000**	.220*	−.184
Na	−.337**	−.133	−.172	.190	.220*	1.000**	−.234*

*Significant at the 5 percent level of probability.
**Significant at the 1 percent level of probability.

with high magnesium contents. High magnesium was correlated to low potassium and high calcium. High levels of potassium were closely related to low levels of calcium. Levels of calcium and sodium were also directly related.

The only relationships found to exist between the chemical elements of the leaf and the grain pertained to nitrogen and magnesium. The plots which produced leaves with the highest nitrogen content, also produced grain with the highest nitrogen content. An inverse relationship was found between the magnesium in the grain and in the leaves. In this latter case, the negative correlation coefficient, $r = -.238$, is significant at the 5 percent level of probability.

Many of the correlation coefficients are relatively low despite the fact that they are statistically significant at the 1 percent level of probability. Such a situation strongly suggests a consistent relationship between the two factors but that the relationship is affected also by factors other than those indicated.

Morrison's (1938) tables show that No. 2 corn contains on the average 1.55 percent nitrogen, .28 percent phosphorus, .33 percent potassium, and .01 percent calcium. The values obtained in this study are not in close agreement with the figures.

Both significantly higher and lower values were obtained for nitrogen in corn grain. Only one of the values representing the phosphorus content was as high as those cited by Morrison. Both lower and higher values were obtained in regard to potassium. Generally speaking, lower values than suggested by Morrison, were obtained for the percent calcium in corn grain.

SUMMARY

Corn which was fertilized with 57 different combinations and rates of nitrogen, phosphoric acid, and potash fertilizers was grown on a Kalamazoo sandy loam soil in 1956. The highest yielding plots produced grain with the highest nitrogen and lowest magnesium contents. Positive correlations were noted between potassium and phosphorus ($r = .292^*$), potassium and magnesium ($r = .282^*$), and potassium and calcium ($r = .309^{**}$) contents of the grain while a negative correlation ($r = -.254^*$) existed between the nitrogen and magnesium contents.

A direct relationship existed between yield and the leaf's nitrogen content ($r = .415^{**}$), while an inverse relationship existed between the sodium content of the leaf and yield ($r = -.234^*$).

Significant negative correlations were found between levels of nitrogen and potassium (r= −.219*), nitrogen and sodium (r= −.337*), potassium and magnesium (r= −.806**), potassium and calcium (r= −.667**), in the corn leaf. Positive correlations were found for phosphorus and magnesium (r=.231*), calcium and magnesium (r=.817**), and calcium and sodium (r=.220*).

The nitrogen contents of the seed and the leaf were directly related (r=.219*) while an inverse relationship existed between magnesium levels in the grain and leaf (r= −.238*).

*Statistically significant at 5 per cent level of probability
**Statistically significant at 1 per cent level of probability

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THERMOCOUPLE ERRORS IN LONG WIRES WITH DIFFERENT TYPES OF INSULATION IN WET LOCATIONS

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COPPER-CONSTANTAN THERMOCOUPLES are standard equipment for making heating and cooling rate tests in canned, bottled, and packaged foods. When thermocouples are used, it is known that the lead wires should be perfectly insulated from the measuring junction to the reference junction. Any secondary circuits will create errors in the temperature measuring system.

In laboratory studies, the thermocouples used are normally less than 20 feet in length and it is not uncommon to find duplex thermocouple lead wire used that is not 100 percent moisture proof. If the product being tested is a can or jar heated in a water bath or retort, the amount of wire that is in the wet location is considerably less than 5 feet. Errors have not been detected when non-waterproof wire has been used.

When thermocouples are used to measure the rate of heating and cooling of glass jars or cans in a continuous pasteurizer, the length of thermocouple wire may be as much as 150 feet. The harness may consist of as many as 24 single wires or 12 duplex leads. The expense and bulkiness of 12 heavy duty duplex insulated wires 150 feet long is obvious and there is a temptation to use light weight duplex wire.

The errors that occur in this system if 24 gage duplex thermocouple wire with non-waterproof insulation is used are very difficult to detect. This is because these errors occur only when the wire is hot and wet, at which time the measuring junction is normally inaccessible for checking against a reference temperature. A project involving

[1]The assistance of Dr. R. N. Costilow in first discovering and correcting these irregularities is acknowledged.

ARTICLE 40-99

the use of long thermocouple leads led to this investigation of the type of errors that occur with different types of thermocouple wires in different environments.

EXPERIMENTAL

Six copper-constantan thermocouples with at least 160 feet of lead wire were constructed. Each pair of thermocouple wires was insulated with a different type of insulation. The six types of wire construction used are listed in Table 1. The 160-foot length was divided into alternate 5- and 15-foot lengths. Each 15-foot length was wound into a hand coil and tied. In this way the effect of the variables in 20-foot increments of wire could be determined.

TABLE 1—Characteristics of the six types of thermocouple wires

Sample number	Wire size B & S gauge	Style	Insulation
1	24	Duplex.....	Polyvinyl, no enamel.
2	20	Duplex.....	Glass fiber braid, impregnated over double-wrap glass fiber, impregnated; enamel on copper wire only.
3	22	2 single wires.	Cotton braid over heat resistant rubber, no enamel.
4	24	Duplex.....	Extruded nylon over extruded nylon, no enamel.
5	24	Duplex.....	Glass fiber braid, impregnated over double-wrap glass fiber, impregnated over enamel.
6	24	Duplex.....	Fiber glass overwrap over glass wrap, no enamel.

A Leeds and Northrup portable potentiometer, model 8663, a Minneapolis Honeywell recording potentiometer, model 153X72P12, and a Leeds and Northrup precision potentiometer, model 8662, were used in making the e.m.f. measurements of thermocouples.

An automatically controlled water bath was used for the water immersion tests, an autoclave for the steam tests and a hot air oven for the dry heat tests. The thermocouples were checked at the ice point and boiling point of water, by either placing the hot junctions of the thermocouples in a thermos bottle containing crushed ice and water, or in boiling water.

Successive 20-foot increments of thermocouple wire were placed in the water bath to determine the temperature sensing error as a function of length of wire in a hot, wet environment. The error was

TABLE 2—Effect of submerged length on temperature error

Length of wire in 195° F. water bath, feet	Error in temperature of ice point and boiling point (°F)											
	Sample No. 1 (polyvinyl)		Sample No. 2 (20 gage glass fiber+enamel)		Sample No. 3 (rubber)		Sample No. 4 (extruded nylon)		Sample No. 5 (24 gage glass fiber+enamel)		Sample No. 6 (24 gage fiberglass)	
	Ice point	Boiling	Ice point	Boiling	Ice point	Boiling	Ice point	Boiling	Ice point	Boiling	Ice point	Boiling
0	2	2	1	−7	1	−2	1	0.5	−3	−2	1	−31
20	3	0	3	−7	1	−2	4	2	−3	−2	4	−16
40	2	0	2	−6	1	−2	18	12	−3	−3	10	−6
60	2	0	2	−5	1	−3	33	24	−3	−3	26	−3
80	2	0	2	−6	2	−2	50	35	−2	−3	71	26
100	2	0	2	−8	2	−2	77	66	−2	−3	..	...
120	2	1	2	−10	1	−3	97	72	−3	−3	..	...
140	2	1	2	−12	2	−2	123	100+	−3	−3	..	...

also determined at both the freezing and boiling points of water (at 1 atmosphere) with each of the six pair of wires at water bath temperatures of 80, 100, 120, 140, 160, 180 and 195°F.

An effort was made to determine the effect of pre-soaking thermocouples before using them for measurements. Two of the thermocouple wires were tested in different environments: flowing steam at 210°F. and an air oven at 206°F.

RESULTS

Table 2 gives the measured errors in the freezing and boiling points of water as a function of length of wire in a 195°F. water bath. A replication of this test gave results qualitatively the same, but quantitatively different. The time allowed for pre-soaking and the integrity of this insulation has an effect on the magnitude of the error. The data in Table 2 were obtained with wires that were thoroughly soaked before testing.

In Table 3, polyvinyl is compared to extruded nylon in water at two different temperatures, steam at 210°F., and hot air at 206°F.

TABLE 3—Effect of environment on thermocouple error (a)

Environment temperature	Error in temperature °F			
	Wire sample 1 Polyvinyl		Wire sample 4 Extruded nylon	
	Ice point	Boiling point	Ice point	Boiling point
Water 100° F.....	0	1	0	2
Water 195° F.....	2	1	123	100+
Steam 210° F.....	4	−2	−24	59
Air oven 206° F....	..	0	...	0

(a) Entire length of lead wire at environment temperature.

Table 4 gives the temperature of the ice and boiling points when the entire length of the polyvinyl and extruded nylon wires are submerged in a water bath at several temperature levels.

TABLE 4—Effect of water bath temperature on temperature measurement (entire 160-ft. length of thermocouple wire submerged)

Temperature of water bath	Indicated temperature of ice point and boiling point (*a*)			
	Wire sample 1 Polyvinyl		Wire sample 4 Extruded nylon	
	Ice point	Boiling point	Ice point	Boiling point
80	33	210	32	209
100	34	210	34	208
120	33	211	39	209
140	33	211	57	208
160	35	212	75	232
180	35	210	106	272
195	34	210	174	300+

(*a*) Boiling point, 211° F.

DISCUSSION

The results point out vividly that thermocouples that are not waterproof will give erroneous results when long lengths are used in wet or damp locations at temperatures above 80°F. The error is a function of the type of insulation on the thermocouple wire, the length of wire that is wet and the temperature of the wet wire. Immersion in steam was just as bad as immersion in water. It was found that if the thermocouples were placed in a hose and cool (50 to 80°F.) water allowed to flow through the hose the thermocouples read correctly.

In studies made to determine the cause of errors, it was found that the system consisting of poorly insulated thermocouple leads in a wet location acts like a battery. This was verified by Robertson[2] and the overall problem is discussed by Dike.[3] The voltage of this battery varied with the length of wire in the water and the temperature of the water.

When the thermocouple junction is made, this battery is short circuited; however, the secondary e.m.f.'s are still of sufficient potential to produce erroneous temperature readings.

[2]Robertson, D. (1956). *Personal Communications.* Leeds and Northrup Co., Philadelphia, Pennsylvania.

[3]Dike, P. H. (1954). *Thermoelectric Thermometry.* Leeds and Northrup Co., Philadelphia, Pennsylvania. 90 pp.

SUMMARY

It must be pointed out that whenever possible, a waterproof wire should be used, and in all cases, the most waterproof wire available should be used. Enameled wires appear to be more resistant to errors encountered in damp locations than unenameled wires, and the polyvinyl and rubber insulated thermocouples appear to have the best qualities for use in damp locations. It was found that if the thermocouples are placed in a tube and cool water at about 70°F. circulated along the wires, correct readings are obtained. It appears that if the thermocouple wires are short or the length of the wire in a damp location is short, i.e. 5 feet, the errors will not be significant.

LEACHING OF FOLIAGE BY RAIN AND DEW AS AN EXPLANATION OF DIFFERENCES IN THE NUTRIENT COMPOSITION OF GREENHOUSE- AND FIELD-GROWN PLANTS[1]

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Department of Horticulture

INTRODUCTION

Greenhouse-grown crops often contain a higher concentration of certain nutrient elements than do the same crops grown out-of-doors. This phenomenon was noted as long ago as 1883 by Councler (1883), and subsequently observed by several other workers (LeClerc and Breazeale, 1908; Mann, 1924; Arens, 1934).

Although many factors may affect nutrient accumulation in plants, LeClerc and Breazeale (1908) and Arens (1934) attributed the lower nutrient content of field-grown crops as compared to greenhouse-grown crops primarily to the leaching action of rain and dew which removed nutrients from the foliage. Recent reports (Tukey, 1958; Tukey, et al., 1958) have supported this concept and have demonstrated the relative leachability of 11 radioisotopes to be as follows, in the order named: Na^{22}, Mn^{54}, Ca^{45}, Mg^{28}, S^{35}, K^{42}, Sr^{90}-Y^{90}, Fe $^{55\text{-}59}$, Zn^{65}, Cl^{36}, and P^{32}.

The purpose of this paper is to relate the leaching of nutrients by rain and dew to differences in mineral content of greenhouse- and field-grown crops.

EXPERIMENTAL

Blueberry. In January of 1957, 1-year-old rooted cuttings of blueberry *(Vaccinium corymbosum)* were established in the greenhouse as part of a sand culture nutrient experiment. A second group of 2-year-old cuttings was established in similar fashion 4 months later.

[1]The financial support of the U. S. Atomic Energy Commission, Biological and Medical Division (Contract No. AT-(11-1)-159) is acknowledged. The authors are indebted to Dr. E. J. Benne and Mr. S. T. Bass of the department of agricultural chemistry for the leaf analyses.

ARTICLE 40-100

In June, all the plants were transferred out-of-doors under a netted shade house (¼-inch mesh) where they grew during the summer. The light intensity in the shade house was lower than in the greenhouse, but the netted tent offered little impediment to the wetting of leaves by rain and dew.

In September, the leaves of the 1-year-old cuttings were collected and analyzed for 10 elements. At the same time, the 2-year-old plants were returned to the greenhouse and grown for an additional 2 months, when the leaves were collected for chemical analysis.

The results of the analyses (mean of all treatments) are shown in Table 1. Levels of all nutrients except copper and iron, were higher in the greenhouse plants than in the field plants. Greatest differences occurred with manganese, calcium, magnesium, and potassium in the order named, indicating that these nutrients were leached in large amounts from mature leaves by rain and dew. The same relation between the nutrient content of the greenhouse and field plants occurred regardless of the nutrient intensity of the root medium.

In a field sampling, the mature tip leaves of blueberry were collected from two positions on 15-year-old commercially-grown plants out-of-doors, namely, from the periphery of the bushes (sun leaves)

TABLE 1—Comparative mineral content of mature blueberry leaves (Vaccinium corymbosum) from plants grown out-of-doors and in the greenhouse

Mineral nutrient	Blueberry (percent dry weight)	
	Out-of-doors	Greenhouse
N	2.25	2.39**
K	0.736	0.920**
Ca	0.47	0.63**
Mg	0.34	0.45*
P	0.22	0.28**
Fe	0.0287	0.0203*
B	0.0231	0.0266
Mn	0.0066	0.0216**
Cu	0.0042	0.0033**
Zn	0.0010	0.0011

* or ** differs from out-of-doors values at the 5 and 1 percent levels respectively.

and from shoot-growth deep inside the bushes (shade leaves). The shade leaves were partially protected from rain and dew by the outside sun leaves.

A lower concentration of all nutrients except calcium, occurred in the sun leaves (Table 2) as compared to the shade leaves. The greatest differences were found in potassium, manganese, boron, and copper. Von Leiningen (1905) also noted this phenomenon in other plants, and Arens (1934) showed that sun leaves were more readily leached than were shade leaves.

TABLE 2—Comparative mineral content of mature blueberry leaves (Vaccinium corymbosum) from two positions on the plant

Mineral nutrient	Leaf position on plant	
	Sun leaves (percent dry weight)	Shade leaves (percent dry weight)
N	1.64	2.32
K	0.313	1.280
Ca	0.55	0.52
Mg	0.28	0.30
P	0.16	0.18
Fe	0.0277	0.0294
Mn	0.0069	0.0243
B	0.0030	0.0074
Cu	0.0015	0.0032
Zn	0.0009	0.0011

These findings suggest that the differences between the nutrient composition of sun and shade leaves of blueberry bushes may arise in part from the leaching of nutrients by rain and dew.

The results with blueberry agree with the relative leachability of isotopes as determined by Tukey (1958) and Tukey et al. (1958). The nutrients which were more readily leached were present at lower levels in the field-grown crops than in the greenhouse-grown crops. These data may explain why the foliage of greenhouse crops often has a higher content of certain nutrients than does that of the same crops grown out-of-doors where rain and dew can leach nutrients from the leaves.

Apple. Many factors other than rain and dew, however, may influence the accumulation of nutrients in plants, such as sunlight, tem-

Fig. 1. Apple trees *(Malus domestica)* were covered with a clear plastic roof as a protection from rain. Sides were open during the experiment.

perature, and humidity. To minimize these effects, eight 5-year-old apple trees *(Malus domestica)* growing in the orchard were selected for study.

Four trees were covered with a roof of clear plastic to protect them from rain, as seen in Fig. 1. The four other trees were left uncovered.[2]

Leaf samples were taken from all trees in September from midway down the new shoot growth, and analyzed as described before.

The results are presented in Table 3. Levels of calcium, copper, potassium, and manganese were significantly lower in the unprotected than in the protected trees, which suggests that these nutrients were leached from mature leaves. Levels of iron, magnesium, and nitrogen were also lower in the unprotected trees, while levels of boron. phosphorus, and zinc were about the same in both sets of trees.

These results again show a lower concentration of leachable nutrients in leaves from trees subjected to rainfall as compared to protected trees.

[2]Trees and plastic covers courtesy of Dr. A. E. Mitchell and Dr. D. W. Kretchman.

TABLE 3—Comparative mineral content of mature leaves of orchard-grown apple trees (Malus domestica) protected and unprotected from natural rainfall

Mineral nutrient	Unprotected (percent dry weight)	Protected (percent dry weight)
N	2.24	2.29
K	1.29*	1.50
Ca	1.44*	1.54
Mg	0.34	0.37
P	0.18	0.18
Fe	0.0353	0.0375
Mn	0.0074*	0.0102
Cu	0.0030*	0.0037
B	0.0026	0.0028
Zn	0.0019	0.0020

*Significantly lower than values from protected trees at the 5 percent level.

SUMMARY

The results presented herein support the hypothesis that the natural leaching action of rain and dew on plant foliage may be responsible for the lower concentration of nutrients in field-grown crops as compared with greenhouse-grown crops. The nutrients which were at significantly lower levels in field-grown crops (exposed to rain) were those nutrients which were predetermined by the isotope-tracer technique as being readily or moderately leached.

Foliar analysis of orchard-grown apple trees showed a lower concentration of leachable nutrients in trees in the open as compared with trees protected from rain by a plastic roof. Similarly, sun leaves of blueberry fully exposed to the action of rain and dew contained a lower concentration of leachable nutrients than did the partially protected shade leaves.

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THE EFFECT OF CLIPPING ON THE YIELD OF WINTER BARLEY

By WILLIAM WESTRATE and J. E. GRAFIUS[1]

WINTER BARLEY sometimes grows very rank in the fall. When this happens, farmers begin asking county agents and others whether they should clip their barley to prevent "smothering." Two questions arise in connection with possible clipping: What would happen to barley yield, and what would be the effect of the rank barley growth on any new seeding of forage crops? This experiment was not designed to answer the second question. Limited field observations in Cass county did not indicate that clipping benefited the seedings. However, the evidence was too meagre to draw conclusions. This report will concern itself with what happened to the yield of winter barley grain when the plants were clipped.

In 1955, Westrate clipped some of the border plots of Hudson barley in the test plots in Cass County. A hedge shears was used, taking the top down to about 1 inch above the soil. Clipping in October caused an average reduction in height at harvest time of 2 inches and reduced yield by 10 bushels.

A more complete experiment was set up in 1956 and the results are given in Table 1.

The effect of clipping to remove what appeared to be an excess of top growth was detrimental to yield of winter barley grain. Clipping on October 21 and May 11 when growth was rank was much more harmful to yield than clipping on October 9 or May 2 when the plants were small and less top growth was removed. The lowered yields secured following removal of a large amount of vegetative growth point out the fallacy of clipping barley to prevent yield reduction.

Pasturing winter barley when the growth is rank will probably affect the yield of grain in much the same manner as clipping, depending upon the severity of grazing and the amount of top growth re-

[1]Soil conservationist, U. S. D. A. and professor of farm crops, Mich. State Univ., respectively.

ARTICLE 40-101

TABLE 1—The effect of clipping on the yield of Hudson winter barley in Cass County, Michigan, 1956

Treatment	Yield in bu./A.
Clipped Oct. 9	41.4
Clipped Oct. 21	38.7
Clipped May 2	43.0
Clipped May 11	34.4
Unclipped	46.3
L.S.D. .05	7.6

moved. If pasture is in short supply, such grazing may have a value equal to or greater than the reduction in grain yields, in which case grazing may be justified.

Clipping tended to reduce lodging as, in both 1955 and 1956, the height at harvest and plant vigor were reduced. In view of the reduced yield, clipping to reduce lodging is a questionable practice.

CORRELATION OF SOIL TESTS, PLANT-TISSUE TESTS, AND YIELD RESPONSE OF SEVERAL CROPS GROWN ON ORGANIC SOILS

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DEPARTMENT OF SOIL SCIENCE

INTRODUCTION

THE INTENSIVE CROPPING PRACTICES in use today have emphasized the need for soil and tissue tests to help farmers determine fertilizer needs.

The organic soils of Michigan comprise about 12.5 percent of the total acreage of the state. Onions, celery, carrots, and table beets are among the more important crops grown on these soils. This study sought to determine the relationship between soil tests; the amount of nitrogen, phosphorus, and potassium applied, the uptake of these elements by the plant, and the effect on crop yields.

Preliminary studies of Bigger, et al. (1953) indicated a highly significant correlation between the amount of phosphorus (P) and potassium (K) applied as fertilizer and the amount extracted from an organic soil by 0.018 N acetic acid soil extractant. Periodic green-tissue tests revealed a seasonal variation in the composition of water extractable P and K in sugar beets and peppermint.

Forsee (1950) showed that potash applied to the soil was reflected in soil tests as well as in tissue tests.

PROCEDURE

Three fertilizer placement and rate experiments were started in 1949. Chantenay carrots, Detroit Dark Red table beets, and Downing Yellow Globe onions were grown. The fertilizer treatments are shown in Tables 1 and 2. The beet and carrot series were replicated

ARTICLE 40-102

TABLE 1—The influence of fertilizer treatment on the yield of carrots and table beets and on the amount of soil phosphorus and potassium, 1952

Pounds 0-10-30 per acre	Placement	Pounds per acre (*a*)				Tons per acre(*a*)	
		P		K			
		Carrots	Table beets	Carrots	Table beets	Carrots	Table beets
400	1 inch below seed...	10	10	102	137	33.1	27.0
800	1 inch below seed...	12	13	123	137	33.8	29.6
800	2 inches below seed.	14	11	121	125	34.8	28.4
800	3 inches below seed.	11	14	125	197	34.6	28.6
800	Drilled in (*b*).....	13	13	119	151	35.0	28.4
800	1 inch to side and 2 inches below seed.	11	10	163	137	34.6	27.8
800 800	Drilled in 3 inches below seed	15	19	246	354	34.6	27.6
L.S.D.**.....		4.6	4.1	68.5	96.0	n.s.	n.s.

(*a*) Averages of four replications. Soil sampled May, 1952.
(*b*) Fertilizer applied in 7-inch bands, 3½ inches deep.
** L.S.D. refers to least significant difference between means at the 5 percent level.

TABLE 2—The influence of fertilizer treatment on the yield of onions and on amount of soil phosphorus and potassium, 1951, 1952, and 1953

Pounds (*a*) per acre	Placement	Pounds per acre(*b*)						Number of 50-pound bags per acre(*b*)	
		P			K				
		1951	1952	1953	1951	1952	1953	1951	1952
400	Drilled in.....	14	14	11	276	265	215	162	249
400	1 inch below seed.....	14	11	11	308	164	168	320	502
600	1 inch below seed.....	15	16	11	339	309	207	381	499
800	1 inch below seed.....	18	16	12	487	270	276	492	563
800	2 inches below seed.....	18	14	12	400	272	207	524	572
800	3 inches below seed.....	19	15	10	392	319	200	577	512
800	1 inch side and 2 inches below seed.....	14	18	11	375	282	231	498	487
800	Drilled in.....	17	18	11	395	291	230	313	399
800 800	3 inches below seed..... Drilled in.....	28	23	14	375	413	259	625	652
400 400	1 inch below seed..... Drilled in.....	18	13	16	356	316	260	425	583
400 400	1 inch below seed..... Side dressed.....	21	16	19	581	228	320	438	532
L.S.D. (5% level).....		4.5	5.5	3.6	124	47.8	45.4	90	112

(*a*) 4-10-20 applied in 1951 and 5-10-20 in 1952.
(*b*) Average of six replications. Soils sampled in September, 1951 and May, 1952 and 1953.

four times and the onion series six times. They were maintained on the same area during the 4-year period.

The plots were sampled in May 1952 and were tested for extractable P and K. The onion plots were sampled in September 1951, May 1952, and May 1953 to determine the effect time of sampling and annual application of fertilizers had on amounts of available soil P and K. Yields of the various crops were determined.

In a second onion experiment, annual applications of nutrients equivalent to those in 1,000 pounds of one of the following fertilizers; 0-20-10, 5-20-10, 10-20-10, 0-20-20, 5-20-20, 10-20-20, 0-20-30, 5-20-30, 10-20-30, 0-10-30, 5-10-30, and 10-10-30 were made on quadruplicate plots in 1952 and 1953. These fertilizer treatments were repeated on one-half of each plot in 1954. (From 1940 to 1951 this area had received 1,000 pounds of 0-10-30 fertilizer every year.)

A starter fertilizer containing 50 pounds of N, 10 pounds of P_2O_5, and 20 pounds of K_2O was applied to the remaining half of each plot.

TABLE 3—The influence of fertilizer treatment on the yield of onions and on the amount of soil phosphorus and potassium, 1953, and 1954

Pounds per acre annually, 1952, 1953, 1954	Soil tests (a)				Number of 50-pound bags per acre (*a*)		
	Pounds per acre						
	P		K				
N-P_2O_5-K_2O	Sept. 1953	May 1954	Sept. 1953	May 1954	1953	1954(*b*)	1954(*c*)
0-200-100	21	18	282	171	1,130	785	806
50-200-100	21	23	296	187	1,134	811	843
100-200-100	24	20	267	179	1,123	868	880
0-200-200	27	21	301	236	1,060	776	830
50-200-200	20	22	276	267	1,101	782	806
100-200-200	15	22	280	225	1,123	795	947
0-200-300	20	23	375	302	1,057	728	863
50-200-300	26	20	357	264	1,085	748	930
100-200-300	24	22	299	304	1,088	756	950
0-100-300	15	15	309	287	960	849	920
50-100-300	14	15	288	289	1,060	787	934
100-100-300	16	17	318	294	1,011	927	932
L.S.D. (5 percent level)	10.0	4.6	84.3	43.5	n.s.	120	n.s.

(*a*) Average of four replications. Soils sampled in September 1953 and May 1954. Tissue samples taken on July 16 and August 1, 1954.
(*b*) Yield from plots receiving 1,000 pounds of fertilizer per acre.
(*c*) Yield from plots receiving only a starter fertilizer containing 50 pounds N, 10 pounds P_2O_5, and 20 pounds K_2O.

The fertilizers were applied at planting time in a band 2 inches below the seed. Downing Yellow Globe onions were grown as the test crop.

An experiment with Utah 10B celery was started in 1953. Four amounts of potash were replicated three times (0, 400, 800 and 1,200 pounds of K_2O per acre). Two hundred pounds of P_2O_5 were applied in 1953 and again in 1954 on one-half of the plots. The other half of each plot was unfertilized in 1954. Fifty pounds of borax per acre were used annually on all plots.

Soil samples from all plots were made up of 10 cores from the 0- to 6-inch layer of an 11-by 60-foot plot. Each sample was screened (2 mm. sieve) and dried at room temperature.

Phosphorus and potassium were extracted from the soil by 0.018 N CH_3COOH, the extractant proposed by Spurway and Lawton (1949). The soil extract ratio was 1:4 and the mixture, with ¼ teaspoon of activated carbon, was shaken for 1 minute. The extractable P was determined by a colormetric method using the ammonium-molybdate-hydrochloric acid solution proposed by Dickman and Bray (1940) and 1-amino, 2-naphthol, 4-sulphonic acid reducing reagent developed by Fiske and Subbarrow (1925).

The extractable K was determined with a photolometer using a red filter (wave length of 650 millimicrons) and employing a sodium cobaltinitrite procedure involving the use of 95 percent ethyl alcohol.

Green-tissue tests were made on the onion leaves from the fertilizer ratio experiment on July 16 and August 1. The object was to determine the relationships betwen the quantity of applied N, P, and K, the uptake of these elements by the plants, and the yield of onion bulbs.

The leaves from 10 onions were selected per plot for green-tissue analysis. The samples were kept cold until the extractions were completed, as outlined by Bigger et al. (1953).

The water soluble N was determined colormetrically by using 10 percent brucine in chloroform. The water soluble P and K were determined by the methods previously mentioned for determining soil P and K.

Sampling errors were determined for soil and green-tissue tests.

RESULTS AND DISCUSSIONS

Data in Table 1 show that rates of fertilizer application were reflected in the soil tests. Highest tests for P and K were obtained

from the plots receiving the greatest amounts of fertilizer. However, no significant increases in yield of either carrots or beets resulted from any of the treatments.

Placement of fertilizer did not significantly affect the total yield. However, when a serious infestation of "black root" occurred, better stands of beets were obtained on plots where the fertilizer was applied by the single band method rather than with a grain drill in 7-inch parallel bands. A soil test of 10 pounds of P and 100 pounds of K per acre supplemented with an application of 400 pounds of 0-10-30 per acre annually was sufficient to produce high yields of either crop.

The data point out that similar crop yields may occur within a wide range of soil test results and fertilizer application rates.

The data in Table 2 show the influence of fertilizer placement on the yield of onions. The yields were significantly higher on plots where part or all of the fertilizer was placed in a band below the seed, or in a band 1 inch to the side and 2 inches below the seed, than they were on plots where the fertilizer was placed with the grain drill in bands 7 inches apart and 3½ inches deep.

Significant differences obtained between placement treatments for both the P and K tests were not consistent and probably should be ascribed to sampling error. However, in 1951 and 1953, the placement of 400 pounds of fertilizer 1 inch below the seed and an additional 400 pounds side dressed generally gave significantly higher P and K tests than some other methods of placement. Conversely, in 1952 this same method of placement gave significantly lower K tests than some of the other methods (Table 2).

The significantly higher P and K tests obtained by this method of placement in 1951 and 1953 may possibly be attributed to larger residual amounts of these elements in the soil. This might be due in part to the later date of application of "side-dress" fertilizer. It may also be due to the fact that fewer nutrients are removed by the crop, as evidenced by generally lower yields obtained from plots receiving this treatment.

By comparing treatments which involved the same methods of placement, the data show that 1951 yields increased directly with rate of fertilizer application.

The residual soil P and K also increased when more fertilizer was applied. The amount of extractable P in the plots receiving 1,600 pounds of fertilizer per acre was significantly higher than in any other plots in 1951. Similar results were obtained in 1952 except where 800

pounds of 5-10-20 were applied 1 inch to the side and 2 inches below the seed or where the fertilizer was drilled in. The same degree of significance, however, did not apply to the extractable soil K but a general increase in K was observed with increased rate of fertilizer application.

The highest yields were obtained in 1951 and 1952 on the plots receiving 800 pounds of fertilizer per acre placed 3 inches below the seed and 800 pounds per acre drilled in. Yields resulting from this treatment were significantly higher than all the other treatments in 1951 except where 800 pounds of fertilizer per acre were placed 3 inches below the seed. In 1952, significantly higher yields were caused by this treatment except where 800 pounds of fertilizer per acre were placed 1 inch below the seed, 2 inches below the seed, and where 400 pounds were placed 1 inch below the seed and 400 pounds were drilled in.

Onions required a higher level of soil P and K for high yields than did carrots or table beets. Where the soil test was about 15 pounds of P and 200 pounds of K per acre, the onion crop required 800 pounds of 4-10-20 or 5-10-20 per acre annually to produce high yields.

Time of sampling is important in interpreting soil test results. In general, less extractable K was obtained from samples taken in the spring than in the fall. In all cases except one, the soils sampled in the fall of 1951 had higher amounts of extractable K than did those sampled in the spring of 1952 and 1953. Time of sampling did not materially affect the amount of soil P. There was no accumulation of P or K from 1951 to 1953 inclusive, even at the higher fertility levels.

In another onion experiment, conducted in 1953 and 1954, rates of fertilizer application were reflected in the soil tests, as shown in Table 3. Less extractable K was obtained from samples taken in the spring than in the fall. As before, the time of sampling did not materially affect the amount of extractable P.

The fertilizers did not significantly affect the yields in 1953. However, in 1954, the plots receiving 100 pounds N, 100 pounds P_2O_5, and 300 pounds K_2O per acre yielded more than did any of the other treatments and in most cases the differences were significant.

The plots receiving only the starter fertilizer, 50, 10, and 20 pounds per acre of N, P_2O_5, and K_2O respectively, produced higher yields in 1954 in every case than did those plots receiving the basic fertilizers without the starter. It is evident from these data that the residual N,

P, and K were sufficient to produce high yields in 1954 when only a starter fertilizer was used.

Fig. 1 shows that on July 16 the water extractable N in the leaves of the onions increased directly with the amount of N applied. There appeared to be a relationship between the amount of N in the onion leaves and the yield of bulbs although the relationship did not exist with onions sampled on August 1.

It is important to select tissue for sampling at a time when the N, P, and K will best correlate with plant needs.

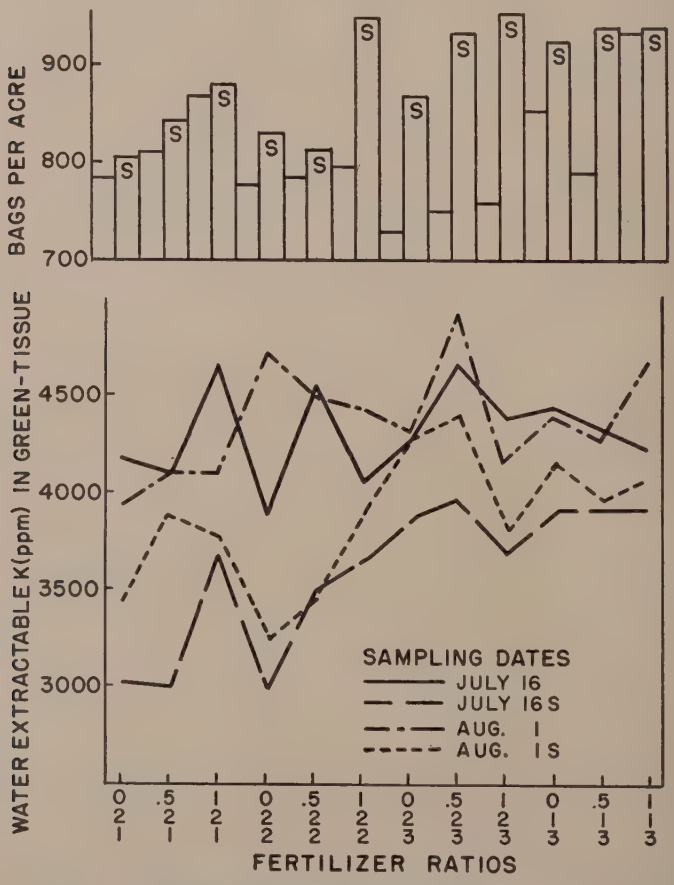

Fig. 1. The effect of fertilizer treatment on the amount of nitrogen in the leaves of onions and the yield of bulbs.

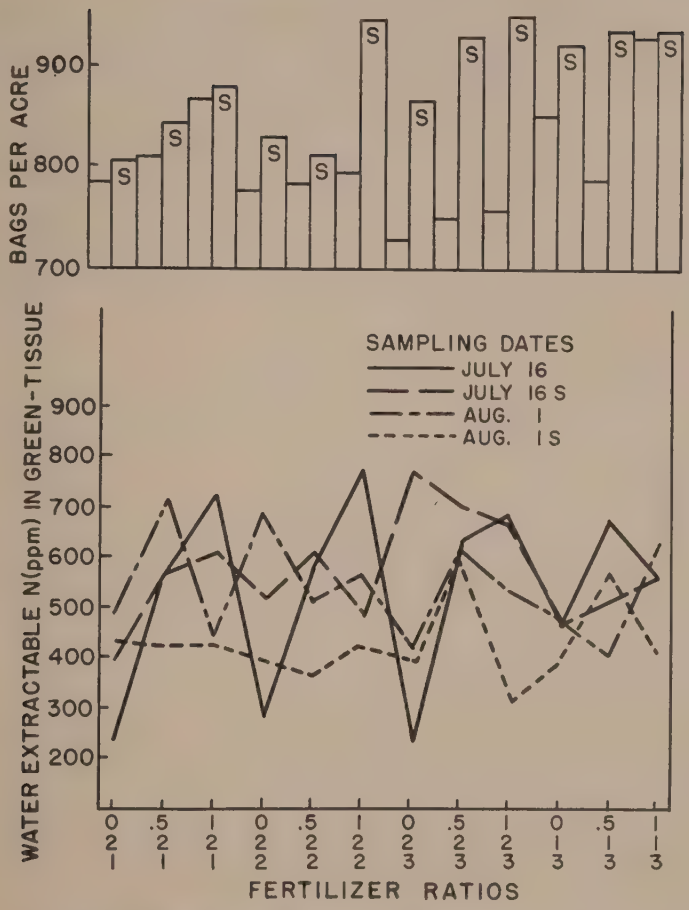

Fig. 2. The effect of fertilizer treatment on the amount of phosphorus in the leaves of onions and the yield of bulbs.

Fig. 2 shows that the water extractable P in the onion leaves sampled on July 16 did not entirely reflect the increased soil P, but in every case except one it was related to the yield of bulbs. This relationship did not exist with the onions sampled on August 1. There was less concentration of P in the onion tissue sampled on August 1 than in that sampled on July 16. This same relationship existed between the two tissue sampling dates receiving the starter fertilizer.

The data in Fig. 3 show no relationship between the amount of K in the onion leaves and the yield of bulbs. Likewise, the applied soil K was not reflected in the leaves of the onion tissue. Generally there was more water extractable K in the onion tissue sampled on August 1 than in the onion tissue sampled on July 16. The reverse relationship occurred for the water extractable N and P as shown in Figs. 1 and 2 respectively.

Table 4 shows that soil tests reflected the increased rates of K application. The highest tests for extractable soil K were obtained

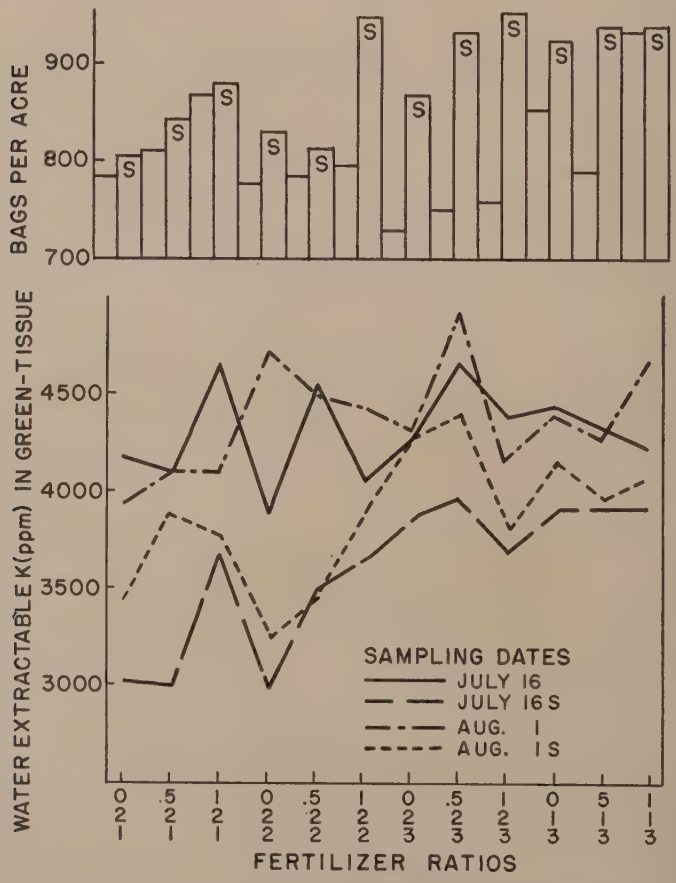

Fig. 3. The effect of fertilizer treatment on the amount of potassium in the leaves of onions and the yield of bulbs.

TABLE 4—The influence of fertilizer treatment on the yield of celery and on amount of soil phosphorus and potassium, 1954

Pounds per acre N-P_2O_5-K_2O	Pounds per acre (*a*)						Tons per acre (*a*)		
	P			K					
	May 24	Sept. 24		May 24	Sept. 24		Fertilized		No fertilizer
		F	O (*b*)		F	O	1953	1954	1954
50-200-0.....	29	33	27	231	157	155	49.6	46.5	46.4
50-200-400....	33	33	28	232	502	321	53.3	51.9	43.4
50-200-800....	39	45	33	768	698	393	50.5	60.0	54.5
50-200-1200...	39	47	35	1,005	1,267	685	46.8	57.2	53.2
							n.s.	n.s.	n.s.

(*a*) Averages of four replications.
(*b*) "F" refers to the fertilized half of the plot in 1954 and "O" to the unfertilized half.

from plots which received the most potash fertilizer; the lowest tests were on soil not treated with potash. The range where fertilizer was applied in 1954 was from 1,267 to 157 pounds per acre.

Yield differences were not significant, but lower yields were obtained from plots which did not receive potash. In each case the half plots fertilized in 1954 yielded more than the half not fertilized since 1953.

On comparing the amount of soil K obtained in May, before fertilization, and the amount obtained in September, after fertilization and crop removal, the data show that in two cases there was a small accumulation of soil K. Where 800 pounds of K_2O were applied in May, the residual soil K was less after the crop had been harvested which indicates this amount was used by the crop and/or was lost through leaching.

On the unfertilized plots, the residual soil K was less after crop removal in every case except one. This one exception may have been the result of a sampling error. The highest yields on the fertilized plots in 1954, were obtained where 800 pounds of K were applied per acre and the spring soil test showed 768 pounds of soil K per acre. The residual soil K, after crop removal, was 698 pounds per acre.

The highest yields on the plots not fertilized in 1954 were obtained where the spring soil test showed 768 pounds K per acre and the residual soil K, after crop removal, was 393 pounds per acre.

The variation in the soil extractable P on the fertilized plots before

and after fertilization, was from 29 to 39 and 33 to 47 pounds per acre respectively. The extractable P in the unfertilized plots varied from 27 to 35 pounds per acre.

The soil test data were based on 10 cores per plot to make a composite sample for analysis. They illustrate that care must be taken to obtain representative samples and thus avoid faulty recommendations. Based on the data obtained in these tests it is doubtful that much increase in yield of celery can be expected from additional amounts of P and K where the soil tests are 30 to 35 pounds of P and 600 to 700 pounds of K per acre.

To determine the error of sampling involved in the experiments previously described, soil samples were taken from 76 plots at the Muck Experimental Farm that had received a uniform fertilizer treatment for a 14-year period. The extractable soil P and K were determined. The standard deviations from the mean were 10 ± 0.3 and 161 ± 2.4 for the extractable soil P and K respectively.

From one to 10 onion plants were taken at random from one plot of the onion fertilizer placement experiment and the water extractable N, P, and K determined. The standard deviations from the mean were 563 ± 16.7, 60.5 ± 4.1, and 3504 ± 21 for the N, P, and K respectively.

These data show that the error of sampling for both the soil and plant tissue was low. Probably five onion plants per plot would be sufficient to obtain a representative sample.

SUMMARY AND CONCLUSIONS

A study was made to determine the relationship between soil tests, the rate and method of placement of nitrogen, phosphorus, and potassium, the uptake of these elements by the plant, and the effect on crop yields.

From the data reported, the following soil test levels and supplemental plant food requirements are tentatively suggested:

(1) Carrots and table beets—a soil test of 10 pounds of P and 100 to 125 pounds of K per acre supplemented with 400 pounds of 0-10-30 per acre annually.

(2) Onions—a soil test of 15 pounds of P and 200 pounds of K per acre supplemented with 800 pounds of 5-10-20 per acre annually, provided the fertilizer is applied in a band 2 inches below the seed.

(3) Celery—with soil test levels of 30 to 35 pounds of P and 600 to 700 pounds of K per acre, no practical increase in yield of celery would be expected from additional amounts of P and K.

Placement of fertilizers is an important factor to consider in interpreting soil tests with crops such as onions. An increase of 30 to 40 percent in onion yields can be expected if the fertilizer is applied in a band 2 inches below the seed rather than in bands 7 inches apart and 3½ inches deep with a grain drill.

The time of sampling green tissue affected both the content and ratio of plant nutrients. Tissue samples should be taken when the nutrient content correlates best with plant response.

Rates of fertilizer application were reflected in the soil tests. In general, less extractable K was obtained from samples taken in the spring than in the fall. Time of sampling did not materially affect the amount of the soil P.

When 800 pounds of K_2O were applied in the spring, the soil K was less after the celery had been harvested than when sampled in the spring suggesting that this amount of K was used by the crop with possible luxury consumption and/or was lost through leaching.

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PRODUCTION IN MICHIGAN BLUEBERRY PLANTATIONS IN RELATION TO NUTRIENT-ELEMENT CONTENT OF THE FRUITING-SHOOT LEAVES AND SOIL

By W. E. BALLINGER, A. L. KENWORTHY, H. K. BELL, E. J. BENNE, and S. T. BASS[1]

MICHIGAN IS A LEADING STATE in the production of the highbush blueberry (*Vaccinium corymbosum L.* or *V. australe*, Small). In 1955 there were about 4,500 acres producing a crop valued at about $4 million (9). The blueberry and other members of *Ericaceae* differ markedly from other crops in their soil requirements. Only a small amount of information concerning their nutritional requirements is available.

Coville was one of the first to show that the blueberry plant is very sensitive to soil conditions (16). Beckwith and Coville (3) stated that the best soil for highbush blueberries in New Jersey was a mixture of peat and coarse sand for the topsoil and a subsoil of sand underlain with a hardpan usually within 3 or 4 feet of the surface.

Johnston (17) described the soil most commonly used for commercial production of blueberries in Michigan as a sandy soil, very acid in reaction, and usually well supplied with moisture. The surface soil is a dark-grey sand 2 to 10 inches thick and the subsoil is a light grey, nearly white sand. Bailey, et al. (2) reported similar findings for good blueberry soil in Massachusetts.

Many workers (18, 13, and 15) report that the blueberry performed best in acid soils with pH values ranging from 4.3 to 4.8. Boller (4), however, was of the opinion that other factors, such as moisture, aeration, and fertility may be more important. These may be duplicated by artificial means, e.g., irrigation, use of sawdust, and liberal application of ammonium sulfate.

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ARTICLE 40-103

Johnston (18) reported that blueberries could be grown on clay soils if enough organic matter was added. Subsoils often crop out in southwestern Michigan blueberry areas. This resulted in poor growth and yield of the involved blueberry plant. Johnston suggested that the organic matter of these areas be increased by growing cover crops and adding acid peat since growth was generally proportional to the amount of organic matter in the soil. In controlled experiments, Johnston (17) found that soil pH was more critical than percent clay in the soil as the determining factor in the growth of blueberry plants.

Stene (26) doubted that blueberries always require a distinctly acid soil. They might grow well within a wide pH range under certain conditions. Growth was dependent upon the availability of various nutrients under a given condition.

Merrill (22) found that a soil of pH 3.2 was too acid. Blueberry plants growing in such soil were of poor growth and usually died. The soil was lower in pH, calcium, and potassium than soil in which healthy plants grew.

Affected plants showed leaf burning, beginning at the tips of terminal leaves and progressing across the entire leaf. This dying of the leaves continued down the shoot into the older leaves until the plants were practically defoliated by late August. Applications of lime to raise the pH to 3.4 to 3.8 prevented leaf scorch and resulted in better growth.

Chandler (6) found that the addition of lime to very acid soil may increase yield. As much as 18 tons of lime per acre added in three applications was not detrimental. Minton, et al. (24) describe symptoms of calcium deficiency on leaves of the rabbit eye blueberry. "Both old and new leaves are scorched at the tips. Later, the leaves are cupped. Leaves are of medium size; plants make moderate growth."

High calcium in the soil may affect the uptake of various other nutrients. Reeve and Shive (25) noted that as potassium in the substrate increased there was a corresponding increase in boron content of the plant. An increase in the supply of calcium resulted in just the opposite effect—inhibiting boron uptake by the plant.

Hill (14) declared that a soil pH of 4.8 was optimum for blueberries, but they could be produced at a higher pH value if attention was given to other needs of the plants. He recommended that a 3- to 4-inch layer of sawdust be applied each year on upland soils with a normally higher pH. On such sites blueberries are quite susceptible to iron

chlorosis, and the plants are weak, dwarfed, and unproductive. Hill corrected the chlorosis on 4-year old plants by adding 100 grams of chelated iron per plant spread evenly and worked into the soil about the base of each plant.

Hitz and Scott (15) reported that research results are too meager and conflicting to allow a very satisfactory understanding of the nutritional requirements of the blueberry. Cain and Galletta (5) compiled a review of the available literature on this subject confirming this view.

The purpose of this investigation, therefore, was to initiate a more extensive study of the blueberry in Michigan using leaf and soil analyses to provide basic information and data concerning desirable conditions for blueberry production.

MATERIALS AND METHODS

Soil and leaf samples were collected in 1955 and 1956 from 55 blueberry sites in 21 plantations in Muskegon, Ottawa, Allegan, and Van Buren Counties. The sites were selected to provide plants of varying vigor and production; those of vigorous, healthy growth were designated as "good"; those lacking in vigor and relatively small in size were designated "poor". From 6 to 10 bushels were selected for sampling in each of the 55 plots.

Leaf samples were taken from shoots ½ to 1 foot long, which arose from a branch containing blueberry fruit clusters. Two leaves were taken from each of several of these shoots to provide about 200 leaves per plot. Each year the samples were taken at a uniform stage of the physiological development of the fruit. This occurred, generally, during the first or second week in July when the earliest fruit had reached full size but prior to a development of anthocyanin in the fruit. Leaf and soil samples for analyses were taken from the south or west side of the bushes, depending upon the direction of the row planting.

The leaf samples were analyzed spectrographically for phosphorus, calcium, magnesium, manganese, iron, copper, boron, and zinc. Nitrogen was determined by the standard Kjeldahl procedure. Potassium analysis entailed the use of a flame photometer.

The soil samples were tested for acidity using a Beckman pH meter. Determination of the three main soil cations (calcium, magnesium, and potassium) was made using a normal, neutral solution of

ammonium acetate. The leachate was dried under heat lamps and then fired in a furnace at 400° C.

The ash was dissolved in 1 percent hydrochloric acid, filtered, and collected for quantitative analysis. Potassium was determined using a flame photometer. Calcium and magnesium were determined titrametrically using a standardized versenate solution, murexide, and Eriochrome black T (F241), according to Cheng and Bray (7).

Cation exchange capacity was determined by re-leaching the same soil sample with 95 percent ethyl alcohol, saturating the exchange complex with sodium from a 10 percent sodium chloride solution, rewashing with 95 percent ethyl alcohol, and then leaching the exchangeable sodium using the neutral, normal ammonium acetate.

The exchangeable sodium thus obtained was then determined using a flame photometer. The exchangeable calcium, magnesium, potassium, and cation exchange capacities were calculated as milliequivalents per 100 grams dry soil. The saturation of the exchange capacity of the three soil cations was calculated on a percent basis.

RESULTS AND DISCUSSION

Only 33 of the original 55 blueberry plots provided yield records for the 2-year period due to frost, dry weather, and other adverse effects on the fruiting of some plantings. The data for each of these 33 sites were averaged for the 2 years, 1955 and 1956, in order to reduce the effects of seasonal and cultural variations, and then correlated to yield.

The degree of correlation between the 2-year averages of yield and nutrient-elements of the fruiting-shoot leaves was determined. The correlation between yield in pounds of berries per bush and percent dry weight of magnesium of the fruiting-shoot leaves, +0.339, was significant at the 5 percent level. This perhaps indicates that some of the plantations surveyed were limited in production by shortages of magnesium.

Scatter diagrams showed no apparent relationships between yield and leaf composition for the following nutrient-elements: manganese, potassium, phosphorus, calcium, zinc, copper, boron, and iron.

There was a highly significant correlation, +0.717, between yield and percent dry weight of nitrogen in the leaves. When leaf nitrogen was above 2.1 percent, however, the correlation was negative rather than positive. As shown in Fig. 1, a nitrogen content exceeding an

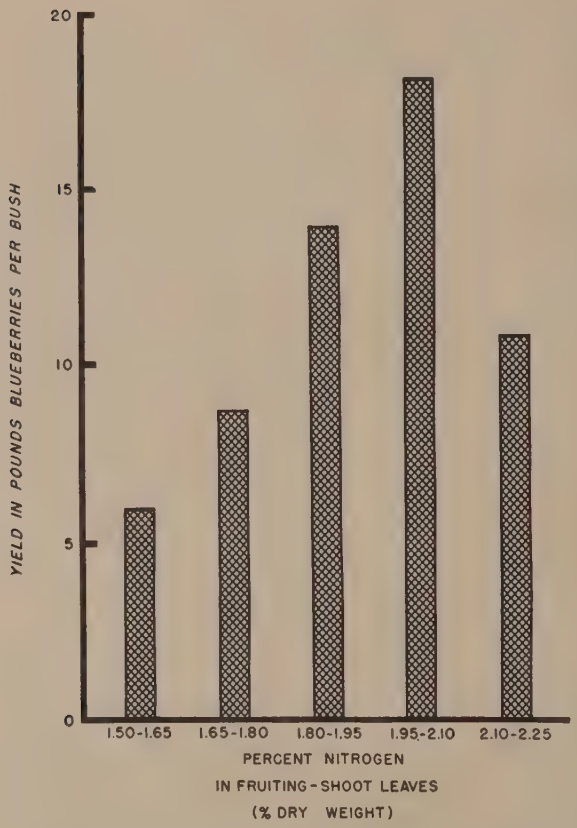

Fig. 1. A comparison of the nitrogen content of fruiting-shoot leaves with the yield in pounds of blueberries harvested per bush.

optimum of approximately 2.1 percent resulted in a marked decrease in yield. Values for individual plots indicated that 60.1 percent of the plots had below optimum, and 16.7 percent had above optimum concentrations of nitrogen in the leaves.

It is generally known that nitrogen is one of the first nutrients to become deficient in soils which have been cultivated for several years and that wild highbush blueberries are found in a soil that is high in organic matter and rich in reserve nitrogen. Many of the light sandy soils often utilized for blueberry plantings, were originally low in nitrogen and organic matter. Clearing of such land and subsequent

cultivation were conducive to an increased oxidation of organic matter and a decrease in nitrogen.

The percentages of the cation exchange capacity of the soil, in the same 33 plots, occupied by calcium, magnesium, and potassium were grouped into four categories based on total cation exchange capacity, i.e. 0 to 5, 5 to 10, 10 to 20, and 20 to 50 milliequivalents per 100 grams soil.

Fig. 2 shows a comparison of the bushes designated at the beginning of the survey as good (of vigorous, healthy growth) and poor (lacking in vigor, abnormally small) in relation to soil analysis. The

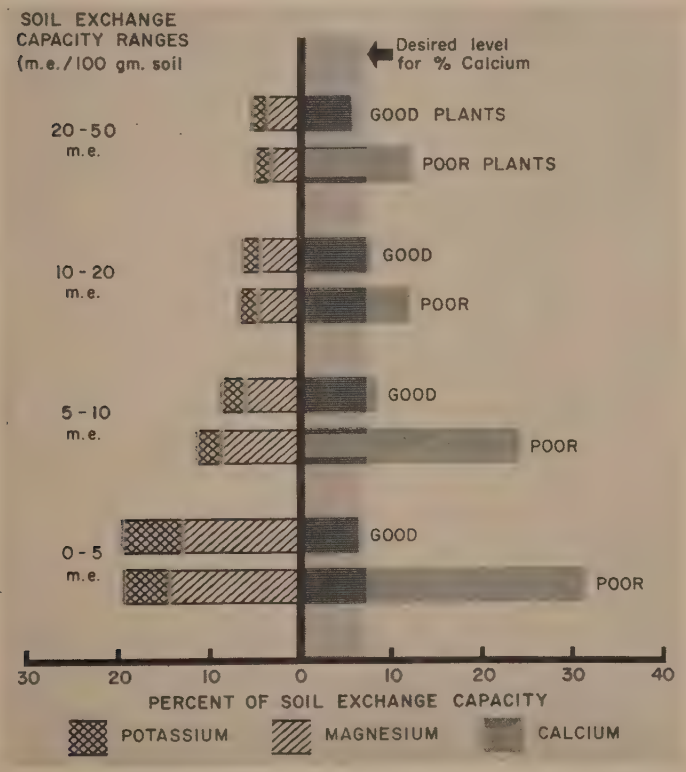

Fig. 2. The effect of the percent of the soil cation exchange capacity occupied by calcium, magnesium, and potassium on the general vigor of the blueberry plant. The averages of bushes designated as "good" in vigor are compared to those of "poor" vigor at each of five soil cation exchange capacity ranges.

average percentage of the total cation exchange capacity occupied by calcium was higher for the poor bushes than for the good bushes. In addition, the percent potassium and magnesium showed no difference between the poor and good categories in each of the exchange capacity groups. The total of the three cation percentages was greater for the poor plants than for the good.

No definite relationship was noted between pH and percent cation exchange capacity occupied by calcium. Likewise, no apparent relationship existed between the total percentage of cation exchange capacity occupied by the three major cations and the pH of the soil. The average percent magnesium and potassium between poor and good bushes did not vary appreciably.

Soils with more than about 10 percent calcium on the cation exchange were associated with poor blueberry plant growth. This information should be quite useful in selecting soil locations for the establishment of new plantations. Plantations already established on such high calcium soils may be modified, perhaps, to give better growth, and vigor to plants thereon. Boller (4) has found mulching to be highly beneficial on soils not ideal for blueberry growing.

Mulching materials, preferably weathered sawdust, will improve soil moisture conditions, allow for an improved growth of fibrous roots, and increase the organic matter content of the soil. The latter attribute seems to be one of the most important since it increases the exchange capacity of the soil. Since the quantity of calcium remains somewhat constant, the percent calcium of the total cation exchange would be reduced. The ability of the soil to retain nutrients applied in fertilizer would also be improved. Johnston (18) reported that blueberries can be grown on clay soil if enough organic matter is added.

These high calcium soils may also be improved by the application of sulfur if the soil pH is above 5.1. Soil bacteria oxidize the sulfur to form sulfate which combines with the calcium, forming calcium sulfate. Since the calcium sulfate is relatively insoluble, the quantity of active calcium would be reduced.

Concurrently, as seen in Fig. 2, the total of the three main cations (in percentage saturations) on the soil exchange was also much higher for poor-vigor plants. The total base content of the root medium of another *Ericaceous* plant, Azalea, was found to be inversely proportional to good growth and foliage color by Colgrove and Roberts (8). Best growth and foliage color occurred when the total base content of the nutrient solutions was reduced to a low level.

Kramer and Schrader (20) conducted experiments with blueberries in which they indicated that this plant has exacting moisture and oxygen requirements, but more important, a high anion and a low cation requirement. They stated that the blueberry has a shallow root system and grows in ". . . high soil acidity where oxidation rather than reduction processes prevail. Since such soils are low in calcium and other exchangeable bases, a low cation requirement is necessary for plants to exist in such an environment. . . .".

Accordingly, such conditions may be causing reduced growth in those blueberry soils that are low in organic matter and relatively dry (Fig. 2). This would lend support to the suggestion made by Doehlert (10) that several integral applications of fertilizer should be made instead of a single application. This method reduces the possibility of getting too great a concentration of cations on the soil at any one time.

Relatively few, if any, cases of potassium deficiency symptoms of blueberry under field conditions have been reported in the literature, although it is possible to induce them in sand cultures, as reported by Kramer and Schrader (19). This may be related to the postulations of Mehlich and Drake (21), and Drake, et al. (11) that the exchange capacities of root colloids influence the absorption of mono- or divalent cations at low levels of soil fertility. Since the blueberry is adapted to a relatively low-fertility soil, this may be of importance in a discussion of its cation absorption.

According to Dunham, et al. (12), plants with a low root exchange capacity are able to accumulate more potassium from low potassium in a nutrient solution than those of a higher root exchange capacity. Drake, et al. (11) found that plants possessing a low root cation exchange capacity have difficulty absorbing divalent cations, such as magnesium and calcium. Since acute deficiencies of potassium have not been observed in blueberries, the blueberry plant roots may have a low cation exchange capacity.

Further, since magnesium deficiencies have been reported in several plantations (23, 1) it may be harder for the blueberry roots to absorb the divalent cations. Blueberries have such a small calcium requirement that calcium is seldom a limiting factor. However, it may produce antagonistic effects on the uptake of other major divalent cations in the soil, i.e. magnesium.

SUMMARY

Relatively little information is available concerning the nutritional requirements of the blueberry. Therefore, a survey was conducted in 1955 and 1956 to determine the existing nutritional conditions of Michigan blueberry plantations.

Approximately 55 blueberry plantings were used for the survey. Soil samples were analyzed for cation exchange capacity, exchangeable calcium, magnesium, and potassium, and pH. Yield records were taken on 33 of these plantings. Analyses were made of fruiting-shoot leaves for nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, boron, copper, and zinc.

The survey revealed that nitrogen was directly proportional to yield when below a maximum of 2.1 percent dry weight in the fruiting-shoot leaves. Above 2.1 percent nitrogen, there was a decrease in yield.

The percent of the soil cation exchange capacity occupied by calcium appeared to affect the vigor of the blueberry plant. Quantities above 10 percent were related to extremely poor growth.

There were some indications that the magnesium content (percent dry weight) of the leaves was related to yield, but may be only of minor influence.

The fact that the blueberry plant is shallow-rooted warrants the use of soil cation exchange determinations as well as leaf analyses in determining the nutritional status of this crop. The soil analysis would indicate the presence of excessive supplies of calcium and would be useful as a pre-planting diagnosis. Leaf analysis would indicate the nutritional needs of the established bushes.

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RELATIONSHIP BETWEEN NUTRIENT-ELEMENT CONTENT OF BLUEBERRY FOLIAGE AND FRUIT

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THE USE OF FOLIAR ANALYSIS of plants has become an increasingly important tool for interpreting the nutritional status of plants. Many data are available in the literature concerning leaf analysis of woody plants and annuals other than blueberry. Cain and Galletta (1954) considered leaf analysis data for blueberry important enough to justify a resume of blueberry leaf analyses reported in the available literature.

The purpose of this investigation was to provide more information and data about leaf composition of the blueberry. An increasing interest in the nutrient-element composition of the fruit of many crops warranted an inclusion of nutrient-element analyses and soluble solids determinations of the blueberry fruit.

EXPERIMENTAL PROCEDURE

Blueberry leaf and fruit samples were collected from 33 blueberry plots in southwestern Michigan. These represented a variety of climate, moisture, and soil conditions and provided plants of varying vigor and production.

During the first year, 1955, fruiting-shoot leaf samples were collected at the time of full development of the blueberry fruit prior to the appearance of anthocyanin coloration. As reported by Ballinger (1957), this occurred about the first or second week of July in Michigan. Sucker-shoot leaves, relatively large in area and not quite as mature, were sampled at the time of fruiting-shoot leaf collection in 1956.

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ARTICLE 40-104

Blueberry fruit was collected for analysis during the second year of the survey, 1956. A 1-pint cardboard container lined with polyethylene was filled with fruit at the peak of the harvest and frozen at −10°F. for analysis at a later date.

The leaf and fruit samples were washed to remove dust, insecticide, and other deposits. They were then dried and ground prior to analysis. Nitrogen was determined by the Kjeldahl method; potassium analysis entailed the use of a flame photometer. Phosphorus, calcium, magnesium, manganese, iron, copper, boron, and zinc were analyzed spectrographically. The results were calculated on a percent dry weight basis.

Yield records were taken for each of the two seasons and averaged to indicate the highest yielding bushes.

RESULTS AND DISCUSSION

The analyses of the nine highest yielding plots were compiled to provide a standard for use in future determinations of the nutritional status of blueberry plantings. Analyses for 2 years, 1955 and 1956, were averaged to provide the fruiting-shoot leaf standard; analyses of sucker leaves and blueberry fruit were available for only 1 year, 1956. These standards are presented in Table 1.

TABLE 1—Standard values for fruit and leaf composition, survey of Michigan blueberry plantations, 1955 and 1956

Nutrient	Fruiting-shoot leaves(*a*) (2-year average)		Sucker leaves(*b*) (1956 analysis)		Blueberry fruit(*c*) (1956 analysis)	
	Percent composition	Coeff. variation	Percent composition	Coeff. variation	Percent composition	Coeff. variation
Nitrogen	1.98	9.0	1.94	7.1	.617	9.9
Phosphorus	.16	17.0	.15	12.7	.070	21.4
Potassium	.527	9.1	.805	5.0	.526	10.3
Calcium	.74	29.1	.66	29.3	.32	43.7
Magnesium	.28	25.4	.19	25.6	.036	17.3
Manganese	.0168	34.3	.0110	67.5	.0017	48.8
Iron	.015	21.1	.010	35.0	.0025	16.7
Copper	.0015	36.5	.0017	14.7	.00061	26.6
Boron	.0049	44.3	.0031	23.4	.00067	10.6
Zinc	.0020	27.0	.0021	25.0	.0046	58.0

(*a*) Leaves collected in mid-July from mid-position of fruiting-shoots of good vigor and production.
(*b*) Leaves collected in mid-July from mid-position of lower, vigorously growing "sucker" shoots.
(*c*) Fruit collected in early August at peak of harvest season from bushes of good vigor and production.

The nitrogen content of both types of leaves was about the same, 1.98 percent for fruiting-shoot leaves, and 1.94 percent for the sucker leaves. The nitrogen content of the fruit was about one-third that of the leaves, .617 percent.

The phosphorus content of the leaves was about the same in both cases, .15 and .16 percent; whereas, the fruit had about one-half this amount, .07 percent. Potassium content was higher in the vigorously growing sucker leaves than in the more mature fruiting-shoot leaves. Potassium content of the blueberry fruit was near that of the fruiting-shoot leaves.

As with phosphorus, the calcium content of the two types of leaves varied little, whereas the calcium content of the blueberry fruit was only one-half as great as that of the leaves. Of the remaining nutrients, zinc was higher in the fruit than in either of the two leaf types. The other elements studied, magnesium, manganese, iron, copper, and boron, were much higher in the leaves than in the fruit.

The coefficients of variation indicated that certain tissues may be more desirable for diagnostic purposes. Using a coefficient of variation of 35 or less as desirable, any of the three tissues analyzed could be used to provide an index of the nitrogen, phosphorus, potassium, or magnesium status of a given blueberry bush. Either of the two leaf types may be used for calcium and zinc. The fruiting-shoot leaves may be used for manganese; either fruiting-shoot leaves or fruit for iron; and blueberry fruits or sucker leaves for boron.

The correlations between the two types of leaves and blueberry fruit in respect to nutrient content for all plantations are shown in Table 2. Manganese was the only element to show a highly significant multiple correlation among any of the three tissues. The boron multiple correlation coefficient was significant only at the 5 percent level. None of the multiple correlation coefficients of the other eight nutrients was significant.

The correlations of potassium, manganese, and iron between fruiting-shoot leaves and the sucker leaves, or the fruit, were highly significant. Nitrogen and calcium showed significant correlations between any combination of two of the three plant samples. Copper and zinc showed no correlation among any of the tissues tested. Phosphorus showed a correlation between sucker leaves and fruit.

These data indicate that due to the degree of correlation for manganese among them, any one of the three tissues, fruiting-shoot leaves, sucker-shoot leaves, or blueberry fruit, may be used as an index of

TABLE 2—Summary of correlation determinations for fruiting-shoot leaves, sucker leaves, and fruit of the blueberry

Nutrient	Fruiting-shoot leaves to: sucker leaves	Fruiting-shoot leaves to: fruit	Sucker-leaves to: fruit	Multiple correlation coefficient
	Linear correlation coefficient (32 D.F.)			
Nitrogen	+0.835**	+0.392**	+0.344*	+0.155
Phosphorus	+0.136	+0.136	+0.561**	+0.318
Potassium	+0.517**	+0.525**	+0.472**	+0.330
Calcium	+0.330*	+0.319*	+0.394**	+0.196
Magnesium	+0.496**	+0.265	+0.320*	+0.117
Manganese	+0.777**	+0.775**	+0.704**	+0.628**
Iron	+0.548**	+0.561**	+0.463**	+0.349
Copper	−0.057	+0.182	+0.073	+0.040
Zinc	−0.035	+0.007	+0.012	+0.000
Boron	+0.640**	+0.254	+0.599**	+0.387*

*Significant at 5 percent level.
**Significant at 1 percent level.

manganese content. However, for nitrogen, phosphorus, potassium, calcium, iron, copper, and zinc, the leaves appear to be the desirable tissue for analysis.

DEFICIENCY LEVELS

During the study, certain areas were sampled where foliar symptoms characteristic of nutrient deficiencies were present. The composition of the fruiting-shoot leaves from these areas is presented in Table 3.

The symptoms characteristic of iron deficiency, as described by Bailey (1936) and Hill (1956), were found in one planting on bushes growing in a soil having a pH of 5.2 with 48.41 percent calcium on the exchange complex. The analyses showed iron to be 53 percent of the standard value established in Table 1. In addition, manganese and magnesium were below the respective standard values. Some leaves showed a complete yellowing characteristic of iron deficiency, while other leaves had an intervenial chlorosis that was more typical of manganese deficiency.

Characteristic magnesium deficiency symptoms similar to those described by Mikkelson and Doehlert (1950), were found in another field and were associated with a magnesium value of .04 percent (36

percent of the standard value given in Table 1). Manganese was 68 percent of standard. Other nutrients were near the standard values except for potassium which was 130 percent of standard.

Symptoms typical of manganese deficiency on other crops were found in still another field and were associated with a manganese value of .0023 percent (46 percent of standard). All other nutrients were near standard values except boron.

Limited trials indicated that a soil application in early spring of 1 ounce of manganese sulfate per bush may cause an increase of 50 p.p.m. in the manganese composition of leaves (from .0056 to .0110 percent). Another trial indicated that magnesium sulfate was about four times as effective as hydrated dolomitic lime upon magnesium composition of leaves. Magnesium sulfate increased magnesium content of the leaves from .14 to .23 percent when applied at a rate of 70 pounds of MgO per acre.

TABLE 3—Composition of fruiting-shoot leaves associated with iron, magnesium, and manganese deficiencies in blueberry plantings

Nutrient	Fruiting-shoot leaves composition—percent dry wt.		
	Iron deficiency	Magnesium deficiency	Manganese deficiency
Nitrogen	1.83	1.66	1.77
Phosphorus	.12	.08	.11
Potassium	.66	.70	1.04
Calcium	.52	.93	1.14
Magnesium	.11	.04	.27
Manganese	.0031	.0086	.0023
Iron	.006	.016	.032
Copper	.0017	.0010	.0020
Boron	.0026	.0029	.0055
Lime	.0020	.0027	.0021

SUMMARY

Samples of fruiting-shoot leaves, sucker leaves, and fruit were collected from 33 blueberry plots in southwestern Michigan.

Fruiting-shoot leaves were similar to sucker leaves in regard to nitrogen, phosphorus, calcium, manganese, copper, boron, and zinc. Fruiting-shoot leaves contained less potassium but more magnesium and iron than sucker-shoot leaves.

Fruit analysis for all nutrient-elements except potassium was below that found for the leaf samples. Coefficients of variation calculated for each nutrient indicated that fruiting-shoot leaves would be more desirable for determining the nutritional status of blueberry plants.

Linear correlation studies showed a significant multiple correlation between the three samples for manganese but not for the other nutrients. The composition of fruiting-shoot leaves showed a better relationship to sucker leaves than to fruit composition. Sucker leaves showed a better relationship to fruit composition than to fruiting-shoot leaves. No significant correlations were found for copper and zinc.

Analyses of leaves from bushes where leaves exhibited deficiency symptoms revealed that symptoms may appear when manganese is below .0031 percent, iron is below .0060 percent, and magnesium less than .11 percent.

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SOLUBLE SOLIDS IN BLUEBERRY FRUIT IN RELATION TO YIELD AND NITROGEN CONTENT OF FRUITING-SHOOT LEAVES

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DEPARTMENT OF HORTICULTURE

MATURITY OF HIGHBUSH BLUEBERRY fruit has been determined by a qualitative method that involves general feel, appearance, and taste of the fruit together with ease of removal from the bush.

During a survey of the nutritional conditions of Michigan blueberry plantations[2], soluble solids determinations were made at each harvest to determine their possible relationship to maturity.

PROCEDURE

Soluble solids determinations were made on the berries during the harvest season. Samples of 10 to 15 berries were taken at random from the picking containers after weighing for yield records. The berries were placed on a 6-inch diameter milk filter pad, which was then folded and twisted until the berries were well squeezed and mixed. A small quantity of the juice was then forced through the filter pad onto a Zeiss-Opton hand refractometer for testing. Three to five samples were tested and averaged from each harvest period. Determinations were read directly in percent soluble solids.

RESULTS

Individual soluble solids readings ranged from 10.19 to 17.89 percent. Seasonal averages, however, had a more narrow range of 11.87 to 17.27. The seasonal mean was 13.99 percent. In many cases, dry weather and lack of moisture in the soil in 1955 resulted in the development of small berries, which were rather hard and firm. In

[1]Dr. Ballinger was formerly research assistant, Dept. of Hort., now assistant professor, Dept. of Hort., N. Carolina State College.

[2]Ballinger, Walter E. (1957). Nutritional conditions of Michigan blueberry plantations. Thesis for degree of Ph.D., Mich. State Univ., East Lansing. (Unpublished).

ARTICLE 40-105

such cases, this small size was accompanied by a soluble solids reading of 16 to 18 percent, which was much above normal.

Soluble solids readings on blueberry fruit, both seasonal averages and those for the first harvest only, are compared to total yield in pounds of blueberries per bush in Table 1. Plot numbers are those for which complete data were available. Drought, frost injury, and other factors precluded the complete collection of data on all plots originally established.

A comparison of the yields and the seasonal averages of percent soluble solids readings reveals a linear correlation ratio of −0.701 which is highly significant at 27 degrees of freedom. Thus, it appears that an increase in yield of blueberries was accompanied by a decrease in soluble solids content.

TABLE 1—Yield and nitrogen content of fruiting-shoot leaves as related to soluble solids content of blueberry fruit

Plot no.	Yield (lb./bush)	Nitrogen (percent dry wt.)	Soluble solids—percent	
			1st harvest	Season's av.
17	24.43	2.20	12.75	13.22
19	24.34	1.94	12.94	12.79
44	23.27	2.19	12.03	12.28
41	22.14	2.18	13.82	13.78
3	20.96	2.23	11.58	12.98
40	20.64	1.73	14.20	14.23
51	20.03	2.16	13.33	13.75
14	19.67	2.11	12.51	12.40
36	18.82	2.04	13.57	13.48
18	18.79	1.98	13.03	14.22
6	18.36	1.92	14.24	14.19
49	15.87	2.16	11.72	12.85
7	15.54	2.23	11.19	11.87
27	15.33	1.99	14.05	14.54
47	14.95	1.91	12.72	14.02
48	13.56	1.65	14.41	14.33
42	13.02	1.96	14.09	14.00
52	12.79	1.87	14.17	13.50
4	12.46	2.35	14.58	15.07
35	12.45	2.25	12.45	13.56
43	10.55	2.05	12.32	13.52
39	10.07	1.63	14.91	14.78
50	8.13	2.04	14.56	15.53
26	7.92	1.80	12.62	15.07
21	5.99	1.97	14.74	14.74
38	5.94	1.80	15.19	15.63
20	3.31	2.06	14.01	14.01
37	1.19	1.61	16.64	17.27

Soluble solids also appeared to be related somewhat to the nitrogen content of the fruiting-shoot leaves. A significant linear correlation of −0.544 was obtained when the seasonal averages of soluble solids readings were compared to the percent nitrogen in the fruiting-shoot leaves. This indicated that soluble solids readings taken at time intervals farther removed from the date of leaf sampling were subjected, possibly, to soil moisture, temperature, and a multiplicity of other variations. In general, however, it appears that a nitrogen-carbohydrate relationship exists in the blueberry plant.

Ballinger (1957) found a highly significant correlation coefficient of 0.717 existed between yield in pounds of berries per bush and percent dry weight nitrogen in the fruiting-shoot leaves. The soluble solids in Montmorency cherries at harvest was influenced by soil management practices that tend to increase tree vigor. In particular, a deficiency of nitrogen and moisture supply at or prior to harvest seemed to increase the content of soluble solids in the cherry fruit.[3]

For blueberries, one may suggest that an excessively high content of nitrogen in this plant or an increase in yield is associated with a low soluble solids content of the blueberry fruit. Conversely, an abnormally low content of nitrogen or a small yield is associated with an increase in soluble solids of the blueberry fruit. This may be some value in estimating either the nitrogen status of the plant or the soluble solids content of the fruit if only one value is available.

SUMMARY

Soluble solids readings of highbush blueberry fruit were taken during the 1955 harvest. These indicated that the range of soluble solids in blueberry fruit was from approximately 10 to 18 percent.

Total yield in pounds of blueberries per bush and percent soluble solids appeared to be highly correlated with a correlation coefficient of −0.701. Soluble solids and percent nitrogen in the fruiting-shoot leaves were also related, with a correlation coefficient of −0.580, which was also highly significant.

The data suggest that a nitrogen-carbohydrate relationship may be of importance in the blueberry plant; that an excessively high nitrogen content, or a large yield of fruit may effect a decrease in soluble solids content of the blueberry fruit. Conversely, an abnormally low content of nitrogen or a small yield may contribute toward a high soluble solids content of the blueberry fruit.

[3]Kenworthy, A. L. and A. E. Mitchell (1952). Soluble solids in Montmorency cherries at harvest as influenced by soil management practices. Proc. Amer. Soc. Hort. Sci. 60: 91-96.

BALANCED PRUNING OF THE CONCORD GRAPE — ANOTHER LOOK UNDER PRESENT-DAY CONDITIONS

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IN 1929, PARTRIDGE[1] introduced the concept of "balanced pruning" for the Concord grape. In balanced pruning, the vigor of each vine is used to determine the severity of pruning. The weight of 1-year-old wood pruned from each vine is used to measure vigor and determines the number of fruiting buds to be left on the vine, as follows:

Weight of 1-year wood	Number of buds to leave on the vine
Less than 1 pound	Less than 30
1 pound	30
2 pounds	40
3 pounds	50
4 pounds	60
More than 4 pounds	More than 60

Growers have felt it impractical and too time-consuming to weigh pruning from each vine. Some prune by estimating the vigor of each vine—the greater the vigor, the greater the number of buds left on the vine. Such pruning might best be called a semi-balanced method, since it is based on a visual estimate. Other growers disregard vigor and treat all vines alike, leaving the same number of buds on each.

Vineyard practices have changed considerably during recent years. Changes in spray programs, fertilizer usage, and soil management practices have resulted in greater vigor and higher yields than were

[1]Partridge, N. L. (1929). Profitable pruning of the Concord grape. Mich. Agr. Expt. Sta. Spec. Bul. 141. 14 pp.

ARTICLE 40-106

found in most vineyards 25 years ago. Because of these changes, a re-evaluation of pruning practices was desired to test the balanced pruning concept under conditions of relatively high vigor.

MATERIALS AND METHODS

A commercial vineyard in the heart of Michigan's Concord grape area was selected for the experiment. The vineyard, located 1 mile south and east of Lawton in the district known as the Lawton Hills, was about 50-years old and planted on a sandy loam soil. Pruning treatments were begun in 1953 and were as follows:

A. Balanced pruning by actually weighing 1-year-old wood removed from each vine (see Fig. 1). The 1-year-old wood pruned from each of five vines was weighed at the beginning of pruning each plot. Buds were counted, and the proper number left according to the pruning weights. The weight of prunings on the rest of the vines in each plot was estimated visually. The number of buds left on each of these vines was according to the estimate of the weight of the 1-year-old wood removed.

Fig. 1. This man is weighing 1-year old wood removed from each vine.

B. Semi-balanced pruning by visually estimating the amount of 1-year-old wood on each vine. In this treatment, the number of buds left on the vine was determined only by the visual estimate of the 1-year-old wood to be removed. No actual weighing of the pruning of wood was involved.

C. Unbalanced pruning according to the general vigor of the entire plot. In this treatment, no attempt was made to estimate the weight of wood removed from individual vines, but the severity of pruning varied according to the general vigor of each plot.

The pruning in treatment A was performed by the authors; in treatment B, by the vineyard owner; and in treatment C, by the vineyard foreman. To avoid bias, each treatment was pruned independently without other pruners being present.

Each plot consisted of a row of 36 vines with four replications of each treatment.

Vines were pruned during the dormant season and yield records were obtained each year.

RESULTS AND DISCUSSION

Fruit yields are summarized in Table 1. For the 5-year period (1953 to '57) of the experiment, average fruit yields under treatment A were significantly higher than under B and C. Treatment A was significantly higher than both B and C in each of the second, third, and fourth years. In the fifth year, there were no significant differences between treatments A and B, but both were significantly higher than C.

This experiment was performed in a high-yielding vineyard where most of the latest vineyard practices are used. The data show that it is possible to increase yields of fruit significantly by weighing prunings, thus, increasing the accuracy of balanced pruning. This suggests that even persons experienced in pruning, who use only visual estimates of vigor prior to pruning, can profit by actually weighing prunings from a few vines each day and leaving fruit buds according to weight of wood removed.

The need for weighing the amount of wood removed will vary with the relative vigor of the vineyard. Checking pruning weights once or twice each day would be sufficient if the vineyard were relatively uniform. However, when moving into a vineyard of dif-

TABLE 1—Influence of pruning upon grape yields—1953 to 57

Year	Av. lb. of fruit per vine for treatments:		
	A(*a*)	B(*a*)	C(*a*)
1953.....	20.2	20.3	19.7
1954.....	23.2	20.8	19.5
1955.....	25.3	24.3	23.8
1956.....	25.8	22.0	23.3
1957.....	21.3	21.5	20.3
Average ..	23.2	21.8	21.3

L.S.D. .05 = 0.81
L.S.D. .01 = 1.15
} for averages between treatments in each year.

(*a*) See treatment description given under "Materials and Methods".

ferent vigor, pruning weights should be checked. The pruner should also check the estimate after pruning often until he can verify his estimate.

Some growers have questioned whether it is economically sound to weigh grape prunings. Table 2 shows the comparative yields of treatments A, B, and C converted to yield per acre and value of the crop per acre for the average of the 5 years of the experiment. The yield conversions were made on the basis of 500 vines per acre. Grape values during 1953 to 1957 averaged $100 per ton.

These results converted to acre and value bases clearly show that balanced pruning by actually periodically weighing the 1-year old wood is not only sound, but profitable. The actual time in weighing

TABLE 2—Influence of pruning upon grapes

	Treatment		
	A	B	C
Av. calc. yield/acre/year (1953 to 57)..	5.8 tons	5.45 tons	5.32 tons
Av. calc. value/acre/year.....	$580.00	$545.00	$532.00
Diff. in favor of A.....	.....	$ 35.00	$ 48.00
Total calc. yield/acre for 5 years.....	29 tons	27.25 tons	26.6 tons
Total calc. value/acre.....	$2,900.00	$2,725.00	$2,660.00
Diff. in favor of A.....	.....	$ 175.00	$ 240.00

should not exceed 5 hours per acre. If labor is valued at $1.00 per hour, the cost in weighing would be $5.00 per acre. The increase in value of the crop of balanced pruning by actual weight over estimated weight amounted to $35.00 per acre per year. The increase in value of balanced pruning over "unbalanced" pruning amounted to $48.00 per acre per year.

HOW LARGE IS THE SURPLUS OF FARM PRODUCTS?[1]

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JUST HOW LARGE are farm surpluses today? And how large are they likely to be over the next decade? How big an adjustment in American agriculture would be involved in the elimination of the flow of surplus commodities? Before attempting an answer to these questions, a distinction must be made between a **stock** of commodities on hand at any one instant of time and the **flow** of commodities produced over a period of years.

When one speaks of the impact of surplus corn upon the price of No. 2 corn in Chicago on May 10, 1958, it is the then existing **stock** of corn in commercial and government hands that has the important economic impact.[2] On the other hand, when someone speaks of adjusting the farm organization and its resources in order to eliminate or reduce surpluses and to raise farm incomes, he should be concerned with the **flow** of excess production over time.

The longer the period of time under consideration, the more important the **flows** of commodities being produced become to the analysis.

Present stocks influence the immediate market price outlook of particular commodities in agriculture. How large are these stocks now?

CARRYOVER STOCKS

Three commodities, wheat, cotton, and corn, constitute the bulk of present surplus stocks.

In 1952, during the Korean War, carryover stocks were at either

[1]The author is indebted to his colleagues, D. E. Hathaway, L. V. Manderscheid, D. E. McKee, and V. L. Sorenson for their criticisms and suggestions in reviewing this paper.

[2]Expectations about the approaching harvest are, of course, of increasing importance the closer one gets to harvest time.

ARTICLE 40-107

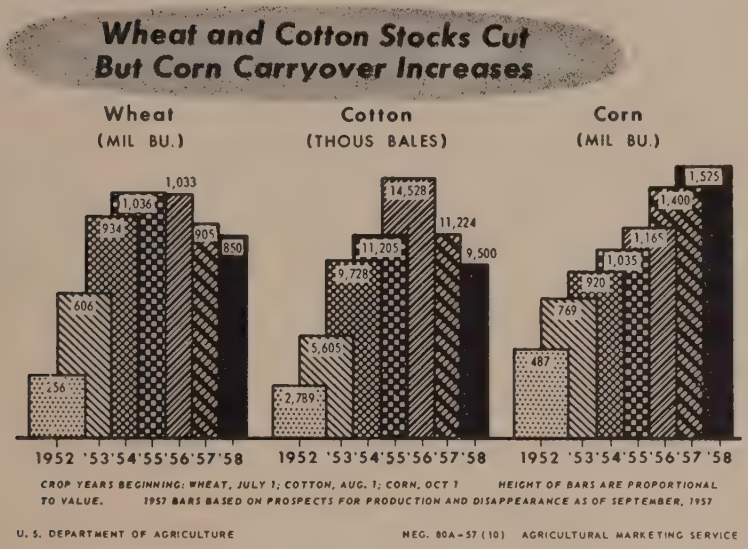

Fig. 1.

exceedingly low levels (cotton and wheat) or at very reasonable levels (corn). By 1956, carryover stocks clearly had grown to excessive levels (see Fig. 1).

In 1957, despite declines in wheat and cotton stocks, the carryover consisted of 908 million bushels of wheat, 11.2 million bales of cotton, and 1.4 billion bushels of corn. This represents 90 percent of a year's consumption and export needs for wheat and cotton and about 50 percent of a year's requirements for corn.

Now, what portion of these supplies are in surplus? Beside annual domestic consumption and export requirements, additional supplies are "desired" as protection against the uncertainties of the world, particularly war and crop failure.

How much of a hedge should this nation have against the hazards of an uncertain world? Professor M. R. Benedict of the University of California provides one answer to this complicated and difficult question. It is his judgment that at present we should probably be maintaining carryovers of around 800 million bushels of corn, 400 to 500 million bushels of wheat, and 5 to 6 million bales of cotton.[3] Some-

[3]M. R. Benedict (1957). Current imbalance of supply and demand for farm products, *Policy for Commercial Agriculture in Its Relation to Economic Growth and Stability*, Joint Econ. Committee, 85th Congress, First Session; 94-99. U.S. Govt. Printing Off., Washington, D.C.

TABLE 1—Carryover stocks brought into the current crop year (a)

Commodity	Units	1957-58 crop year supplies			1952-56 annual average			Carryover as a percent of disappearance	"Desired" carryover level	
		Date of carryover (1957)	Size of carryover into 1957-58 crop year	Total supply 1957-58 crop year	Exports	Domestic consumption	Total disappearance		As percent of annual disappearance	In physical quantities
					In millions of units					Mil. units
Feed grains..	Tons.....	(b)	48.9	192.3	5.2	110.1	115.3	42.4	20 to 25	23 to 29 tons (d)
Corn.....	Bu.....	1 Oct.....	1,419.6	4,823.0	131.2	2,932.6	3,063.8	46.3	25	800 bu.(c)
Wheat.....	Bu.....	1 July.....	908.4	1,843.0	340.9	617.5	958.4	94.8	40 to 50	400 to 500 bu.(c)
Rice.....	Cwt.....	1 Aug.....	19.5	61.6	23.7	26.7	50.4	38.7	7 to 15	3.5 to 7.5 cwt.(d)
Cotton.....	Bales....	1 Aug.....	11.2	23.9	4.0	8.9	12.9	86.6	40 to 45	5 to 6 bales (c)
Tobacco										
Burley.....	Lb.....	1 Oct.....	1,299.0	1,789.0	31.8	492.2	524.0	247.9	150 to 200	800 to 1,000 lb.(d)
Flue-cured.	Lb.....	1 July.....	2,511.0	3,495.0	458.8	756.6	1,215.4	206.6	150 to 200	1,800 to 2,400 lb.(d)

(a) U.S.D.A.
(b) Corn and sorghum grain October 1, 1957; oats and barley July 1, 1957.
(c) Professor Benedict's estimate. See footnote No. 3 in text.
(d) Estimated by the author.

what similar estimates were made in a U.S.D.A. study of reserve levels for storable products.[4]

We have a carryover of corn that is currently almost half a year's requirement. Dr. Benedict estimates that only one quarter of a total year's consumption and export requirements is needed. We may conclude then that about 45 percent of the present carryover of corn is in excess of the nation's estimated needs. The carryover is expected to be even larger at the end of the 1957-58 crop year.

The present carryover of wheat is over 90 percent of an average year's consumption and export requirements. According to Dr. Benedict, 40 to 50 percent of a year's requirements approximate the "desired" level of carryover. Thus, by this standard, half of our present carryover stock of wheat is pure surplus. By the end of the present crop year the carryover is expected to drop slightly to around 880 million bushels.

Dr. Benedict considers 5 to 6 million bales of cotton the "desired" level of carryover. We actually had an 11.2 million bale stock on August 1, 1957. Thus, about half of the present carryover is surplus stock. The stocks of cotton carried over are expected to decline to about 8.7 million bales by August 1, 1958.

In general, for wheat, cotton, and corn we now have about twice the carryover that seems "desirable." These three commodities account for 85 to 90 percent of the Commodity Credit Corporation investment in inventory.

Other commodities also exhibit excess carryovers. What has been said about corn holds true for feed grains in general. This is partly because corn constitutes the bulk of all feed grain supplies. Also, as allotments have limited the acreages of many other crops, barley, oat, and grain sorghum production has been increased.

An all time record for feed grains, 48.9 million tons, was carried into this present crop year. As with corn alone, this is almost twice as large a carryover as can be justified. There is every indication that the carryover will be even larger, about 60 million tons, at the end of the present crop year.

Stocks of rice became excessive in 1955 and rose in 1956 to 36 million hundredweight, which is 6 to 7 times larger than has been estimated as "desirable". The present carryover of rice from the last

[4]Karl Fox, and O. V. Wells (1952). Reserve levels for storable farm products: A study of factors relating to the determination of reserve levels for storable farm products. Senate Document No. 130, 82nd Congress, Second Session: 4-7. U.S. Govt. Printing Off., Washington, D.C. Both this study and that by Dr. Benedict take into consideration yield variation, demand variability, "pipeline needs," war contingency reserves, and storage costs.

crop year is 19.5 million hundredweight, still 3½ times the "desired" level. A further reduction to around 15 million hundredweight is expected by next summer.

Tobacco stocks have been very large in the last few years, but now seem to be adjusting downward as the industry has accepted increasingly stringent acreage limitations. Due to the nature of the curing process, the tobacco industry has a normal carryover of around a 1½- to 2-year supply of tobacco. The carryover of flue-cured tobacco is presently near the upper end of that range. Burley tobacco carryover, however, amounts to about a 2½-year supply which is clearly too large.

To summarize:

1) Corn: About 45 percent of present stocks are in excess of justifiable levels.
2) Feed grains: Like corn, around 45 percent of all feed grain carryover is in excess of the "desired" level.
3) Wheat: 45 to 55 percent of the present carryover is surplus.
4) Rice: Somewhere around 70 percent of the current stock of rice is in excess of justifiable carryover requirements.
5) Cotton: 45 to 55 percent of the present carryover stocks are surplus.
6) Tobacco: Something like 30 percent of the current stocks of burley and perhaps 15 percent of flue-cured stocks are in excess of justifiable carryover levels.

About half of the carryover maintained in these commodities is clearly in excess of the nation's needs. This means that at least ⅔ of Commodity Credit Corporation holdings of these commodities and perhaps as much as ¾ is pure surplus stock.

Stocks, however, are not the most important dimension of the surplus. The really crucial element over the long-run is the existence of a continuing annual output of production in excess of regular commercial consumption and exports. If there were no flow of excess production to be faced, carryover stocks, even twice as large as at present, would mean little more than a few years of inconvenience and cost to society.

As it stands, however, the relationship between the production and

consumption of farm products is structurally out of balance.[5] Chronic, not temporary, overproduction plagues American agriculture today.

ANNUAL FLOW OF SURPLUS PRODUCTION

How large is the current imbalance between agricultural production and consumption? Research done by John F. Stollsteimer indicates that, during the period since the Korean War, the American farmer produced about 8 percent more farm commodities each year than normally would have been consumed at prevailing commercial market prices.[6]

Actually, we have been able to dispose of much of this annual **flow** of surplus production, but only through extraordinary governmental measures. Extensive export subsidy, free donation and barter abroad, and highly accelerated welfare program distributions of food at home are examples. Efforts such as these do not reduce the basic imbalance; they only absorb temporarily a portion of the flow of farm commodities.

The degree of imbalance between production and consumption differs greatly among farm products. The largest annual surplus flow occurs in food grains, cotton, and feed grains, in that order.

Over the period since mid-1952, the Commodity Credit Corporation has, on the average, taken 35 percent of all wheat and other food grains produced off the market each year. In short, at prevailing commercial market prices, we are producing 54 percent more food grains (primarily wheat) each year than the market will handle at those prices.

Each year on the average since mid-1952, 23 percent of all the cotton produced has gone into Commodity Credit Corporation stocks. In other words, we are producing almost ¼ more cotton each year than commercial markets can handle at prevailing prices. Much of what went to the Commodity Credit Corporation was disposed of at less than market price and the rest added to carryover.

Over the same period, corn and other feed grains have moved into or through CCC hands to the extent of about 10 percent of the volume produced.

[5]James T. Bonnen (1957). American agriculture in 1965, Policy for Commercial Agriculture in Its Relation to Economic Growth and Stability, Joint Econ. Committee, 85th Congress, First Session: 145-156. U.S. Govt. Printing Off., Washington, D.C.

[6]John F. Stollsteimer (1937). Effects of government loan and purchase programs upon domestic market supplies of farm products in the post-war period. Thesis for degree of M.A. Mich. State Univ., East Lansing. (Unpublished)

TABLE 2—Annual flow of surplus production as a percent of total production for various farm commodities (a)

Commodity	1952-1953	1953-1954	1954-1955	1955-1956	1952-56 Av.
Food grains (*b*)	27.4	37.7	41.8	32.8	34.6
Feed grains (*c*)	7.0	10.4	9.5	11.4	9.6
Cotton	12.2	21.8	8.8	40.8	23.4
Tobacco	5.1	4.4	9.4	3.1	5.5
Dairy products	2.2	6.7	6.1	3.1	4.1
Livestock (excl. dairy) (*d*)	0	0	0	0	0
All farm products	5.8	10.5	8.0	9.3	8.4

(*a*) The figures in this table are computed by dividing annual gross CCC removals by the index of farm output for the various commodities over their relevant marketing years. The data for the table come from John F. Stollsteimer, (1957) op.cit.

(*b*) Food grains include wheat, rye, and rice, but only wheat and rice are of any significance.

(*c*) Feed grains include corn, oats, barley, and grain sorghums.

(*d*) In no calendar year have CCC removals of livestock products totaled as much as ½ of 1 percent of total livestock production (exclusive of dairy).

Since mid-1952, a volume of tobacco has moved into or through Commodity Credit Corporation hands each year equal to 5.5 percent of all the tobacco produced.

Significant amounts of butter, cheese, and powdered dry milk have been purchased by the Commodity Credit Corporation over the past few years. Since 1952-53, this flow of CCC purchases has averaged each year around 4 percent of the total volume of milk produced on the farm.

To summarize: Surplus is defined here as the annual flow of production going to the Commodity Credit Corporation. This volume of CCC purchases divided by total farm output provides a statement of the relative size of the annual flow of products which commercial markets cannot, or at least do not, handle at prevailing commercial prices.

Thus, over the period 1952-53 to 1955-56, the flow of surplus going into Commodity Credit Corporation hands averaged:

1) 35 percent of all food grain production,
2) 10 percent of the feed grains produced,
3) 23 percent of all cotton produced,
4) 5.5 percent of all tobacco production, and
5) 4 percent of total dairy production.

Since mid-1952, the total flow of agricultural surplus going into or through the Commodity Credit Corporation has averaged over 8 percent of total farm production.

THE FUTURE BALANCE BETWEEN PRODUCTION AND CONSUMPTION

Is this fundamental imbalance of 8 percent between production and consumption likely to widen or grow smaller?

Many things condition long-run changes in the production and consumption of farm products. Population increase is the most important factor in the growth of consumption. In mid-1957, United States population stood at 171 million. The Bureau of the Census estimates that total population will be 193 million persons by 1965, a 13 percent increase.[7] In addition, the per capita consumption of all food can be expected to increase by about 3 percent. Consequently, total food consumption should increase about 16 percent between 1957 and 1965.[8]

Estimates of the impact of organizational and technological change on farm production have been constructed.[9] These estimates indicate that, using the same amount of resources (e.g., land, capital, livestock inventory), agriculture could easily produce 20 to 25 percent more farm output. Implied here is a potential excess production flow by 1965 of around 15 percent per year. Of course, some rather drastic things, both political and economic, very likely would happen before an annual imbalance got that large. But this is a good indication of the pressures which the farmer, and American agriculture generally, is likely to be subjected to over the next 5 to 10 years.

Consider the specific cases of the three major surplus crops: wheat, cotton, and corn. Despite the 13 percent increase in population, total domestic wheat consumption and export requirements should remain near present levels or possibly decline slightly. Yet it is expected that by 1965 we shall be able to produce nearly 10 percent more wheat on present acreage. This is due to an increase in wheat yields.[10]

Total annual cotton requirements for 1965 will remain near the present level of 12½ to 13 million bales. The expected yield increase

[7] Meyer Zitter (1955). Revised projections of the population of the United States, by age and sex; 1960 to 1975, *Current Population Reports*, U.S. Bureau of the Census, Series P-25, No. 123.
[8] James T. Bonnen (1957). op. cit.
[9] *Ibid.*
[10] *Ibid.*, the projections and computations for particular commodities which follow are also from the same source.

in cotton production comes to around 40 percent, lifting average United States cotton yields to more than a bale of cotton per acre by 1965. Naturally, when this is combined with existing over-capacity, it will place the most intense pressure on the human and other resources engaged in the production of cotton.

A rather substantial increase in livestock inventories is expected by 1965. This should be the most rapidly expanding sector of agriculture. As a result, around 12 percent more feed grains will be needed by 1965. However, we are overproducing by almost that much right now, and corn yields are expected to increase at least an additional 9 percent. Barley, oats, and grain sorghum yields are expected to increase somewhat more. Thus, on our present acreage of feed grains we could be producing at least 10 percent more by 1965.

Total tobacco consumption and export is expected to increase only slightly, while the yields of tobacco will probably increase by about 14 percent.

Total milk consumption is expected to grow about 8½ percent by 1965. Milk production per cow should increase 15 percent and the efficiency of feed utilization is expected to improve by about 5 percent, thus adding significantly to the economic pressure being placed on the average dairy farmer.

Clearly then, in none of the major farm commodities now in surplus will the pressure of excess capacity lessen before 1965. Our capacity to produce will continue to grow more rapidly than consumption, thus, potentially at least, enlarging the present imbalance and increasing the resulting flow of surplus production.

CONDITIONS FOR A LOWER OR NO SURPLUS

There are only two situations which are likely to reduce or eliminate the present and expected flow of excess production. Neither are very attractive potentialities.

War is one of these. Any war would immediately lift food and fiber needs to the point where all stocks and practically any excess capacity would be a welcomed asset. This would be true for a limited war such as occurred in Korea as well as for a total war.

Severe agricultural depression is the other situation in which present excess capacity might be eliminated. Not just any depression would do it. However, if agriculture experienced a continuous and

severe depression of 5 to 10 years, while the rest of the economy remained prosperous, it might be possible to absorb present excess capacity.

Most of the capital for the past growth in agricultural capacity has come from farmer's savings and from inflation which has produced capital gains on land and other fixed assets owned by farmers. Both cease to be possible sources of investment funds during a severe and sustained depression.

Improvements in farm organization and technology which require additional capital, consequently, could not be made and capacity would cease to grow as rapidly.[11] After some time in a sustained depression, the efficiency and capacity of many farms is actually reduced by physical deterioration of plant and equipment that is not replaced as it wears out.

If, at the same time, the rest of the economy is prosperous, and population and per capita consumption continue to grow, the gap between consumption and farm production might narrow and possibly close.

CONCLUSION

Barring the calamity of war or severe farm depression, over the next 10 years, surplus production is likely to be a continuous and prominent feature of the agricultural landscape. Half of our present carryover stocks are pure surplus. Currently each year about 8 percent of all farm production goes to the Commodity Credit Corporation. The most reasonable expectation at present is that this surplus flow will grow larger. Clearly the pressures on the returns earned by people and resources in agriculture will increase over the next 5 to 10 years.

In the difficulties over surpluses and declining farm incomes many solutions are suggested. In considering any "solution" certain characteristics of farm input and output should be kept in mind.

An attempt to reduce the flow of surplus commodities by moving large amounts of one resource, such as land, out of agricultural production is doomed to failure. Other resources are simply substituted for land. The limited acreage is irrigated, more fertilizer is put out; in short, the restricted acreage is cultivated more intensively. And

[11] Rapid and general introduction of vertical integration to agriculture would probably alter this conclusion to the extent that it altered the ease of access to and conditions of capital acquisition for different sectors of agriculture.

with higher yields, production usually remains at previous levels or increases still further.

It is often said that there are too many people in agriculture for everyone to earn a good living.[12] This is true. Millions of farm families, particularly those on small farms, will have to turn to other occupations if they are to earn better incomes.

On the other hand, it does not follow from this that the income problem of commercial farmers can be solved and the surplus eliminated just by encouraging people to move out of agriculture. Who would move out? The more productive farmer? The small or low income farmer? Certainly the more efficient management and labor is unlikely to be the first to move to other occupations.

On the other hand, if everyone of the 1½ million non-commercial farms left agriculture, total farm production would not be reduced more than two percentage points (see Table 3). In reality, the effect would probably be even less than two percentage points since as the non-commercial size farmers left agriculture at least some of their farm land would probably be absorbed into larger units under better management.

Two million commercial farmers produce 90 percent of all agricultural output (see Table 3). To lower annual output by 8 percent and eliminate surplus production would involve the movement of close to 2½ million farmers, their families, **and their land and equipment** out

[12]T. W. Schultz (1957). The United States farm problem in relation to the growth and development of the United States economy, Policy for Commercial Agriculture in its Relation to Economic Growth and Stability, Joint Econ. Committee, 85th Congress, First Session: 2-14 U.S. Printing Off., Washington, D.C.

TABLE 3—Distribution of U.S. farms by economic class and volume of sales, 1954 census (a)

Census class of farm by value of farm products sold	Percent of sales		Number of farms	
	By class of farm	Cumulative	By class of farm	Cumulative
$25,000—or more	31.3	31.3	134,003	134,003
$10,000 to $24,999	26.9	58.2	448,945	582,948
$ 5,000 to $ 9,999	20.5	78.7	706,928	1,289,876
$ 2,500 to $ 4,999	12.1	90.8	811,965	2,101,841
$ 1,200 to $ 2,499	5.7	96.5	763,348	2,865,189
$ 250 to $ 1,199	1.4	98.0	462,427	3,327,616
Non-commercial farms	2.0	100.0	1,455,404	4,783,020

(a) *1954 Census of Agriculture*, (1956) Bureau of the Census, Washington, D.C., 2: 1,132.

of the less productive side of agriculture. Two and one-half million farmers are over half of all the farmers in agriculture today. This represents well over 10 million people!

Other questions arise. There is no compelling economic or social reason why agriculture should absorb by itself the full impact of organizational and technological change so general, rapid, and fundamental as to constitute a "revolution" in agriculture. Indeed, part of the impact derives from innovations occurring well outside of agriculture. Few industries of comparable size have faced such rapid adjustment over so short a period of time. One must answer the question of whether the human agent of production in such an industry should be expected to absorb the major impact of so immense an adjustment.

In recent years the flow of people out of agricultural employment has been at record levels. How much acceleration in this migration is possible before the increasing social costs of large scale human readjustment offset the added gains of a better structural adjustment of production and consumption? Indeed, can the long-run movement of people out of agricultural employment be made rapid enough to **more than** offset the production increasing effect of a continued rapid rate of technological and organizational change?

It also must be recognized that in reducing output 8 percent, if the 2½ million farmers who would have to leave agriculture are not distributed properly, the 8 percent reduction will not occur in the surplus commodities. The exodus of farmers from the cotton areas of the South would have little, if any, economic effect upon wheat production in the Plains states.

Both the size as well as the nature of the adjustment facing agriculture make the problem complex. No simple idea or single adjustment has much chance of "solving" the problem. This, plus the fact that it is **people** who are involved, should give particular pause to those who would recommend rapid mass migration as a solution to a current surplus of production and consequent declining commercial farm incomes.

THE EVALUATION OF PICKLING CUCUMBER VARIETIES FOR MICHIGAN[1]

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IN 1950 THE AVERAGE yield per acre of pickling cucumbers in Michigan was 30 bushels; less than half of the yield obtained in previous years. Since 1950, Michigan yields have increased each year, and the average for 1957 was 125 bushels per acre. This higher yield is due primarily to the introduction of varieties resistant to the fungus disease, scab *(Cladosporium cucumerinum),* and the virus disease mosaic, as well as the use of better cultural practices on larger acreages.

In 1950 scab almost destroyed the Michigan and Wisconsin cucumber crops. In 1951 the Wisconsin Agricultural Experiment Station released Wisconsin SR-6 (Walker, et al., 1953), a scab resistant variety, which was quickly adopted in areas where scab was the predominant problem.

The mosaic resistant varieties Yorkstate (Munger, 1950), and Ohio MR-17 (Wilson, et al., 1951) were also released and put into production in Ohio, Indiana, and Southern Michigan, where mosaic was a major problem. It soon became apparent that the "ideal" variety should be resistant to both diseases.

The industry was concerned over the shape, color, and processing quality of the new varieties. In 1954, cucumber variety trials were initiated in Michigan to compare commercially grown with new varieties and breeding lines. Varieties were evaluated for disease resistance, shape, color, and processing quality, as well as yield.

[1]The authors wish to acknowledge the assistance of Michigan processors of pickling cucumbers for helping in quality evaluations, and particularly the H. W. Madison Co., which provided facilities for salting the samples. The help of J. L. Etchells of North Carolina State College in evaluation procedure is acknowledged.

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METHODS

In 1954, trials were planted in Ingham, Berrien, Oceana, Newaygo, and Montcalm Counties. The following varieties were included: National Pickling; Wisconsin SR-6; Ohio MR-17; Model; three experimental lines from the University of Wisconsin (SMR-3, SMR-9, and SMR-12), resistant to both mosaic and scab (Walker and Pierson, 1955); and an experimental variety from Michigan, M.S.U. No. 1, also resistant to both diseases. Ohio MR-25 (Wilson, et al., 1954) was tested in Ingham County.

The trials were laid out as randomized blocks. There were three replications in Ingham and Berrien and two in the other three counties.

Brining samples from each location were chosen from fruits picked August 11 and September 9, and placed in standard salting tanks at the H. W. Madison Company Plant, Mason, Michigan, within about 24 hours of picking. The salt stock samples were removed in January, 1955, and evaluated for processing quality.

In 1955, trials were conducted in Ingham, Berrien, Montcalm, Bay, and Sanilac Counties with the following varieties: Wisconsin SR-6, Ohio MR-17, Wisconsin SMR-9, SMR-12, SMR-18, and two new experimental dual resistant lines from Wisconsin as well as M.S.U. No. 1. Ohio MR-25 was included in the Ingham County trials, along with eight other experimental lines.

Three replications were used in a randomized block in Ingham, and two replications at the other four locations. Where possible, samples from harvests made on the mornings of August 3 and August 25 were collected and brined for salt stock evaluations as in 1954.

In 1956 and 1957, trials were carried out only at East Lansing, comparing the following varieties with five experimental lines: Nappa 63, Ohio MR-17, Ohio MR-25, Wisconsin SR-6, SMR-12, SMR-15, and SMR-18.

The 12 entries were tested in randomized blocks with three replications using plots of two rows 25 feet long. Cucumbers from four harvests of each variety were placed in brine in 1956, and from five harvests in 1957.

Length/width ratios were determined by using a measuring device adapted from a model provided by H. J. Heinz Co.[2] Pressure tests were made on 1 to 1½-inch diameter cucumbers, using a U.S.D.A. fruit pressure tester, with a 5/16-inch diameter tip.[3]

[2]Developed by H. H. Mottern formerly of the H. J. Heinz Co., Bowling Green, Ohio.

[3]The assistance of J. A. Cook in making fruit pressure tests is acknowledged.

RESULTS

Yield

The yield data from the commercially available varieties tested are presented in Table 1. In Ingham and Berrien Counties where mosaic was severe, the yield of Wisconsin SR-6 was usually less than resistant varieties. Although severely mottled fruits were classified as culls, the quality of the marketable fruit was inferior because of the impossibility of grading out all the fruit having mosaic.

TABLE 1—Yield of commercially available cucumber varieties, 1954-1957

Marketable yield (bushels per acre), location, and year

Variety	1954			1955			1956	1957	Av.
	Ingham	Berrien	Oceana	Ingham	Berrien	Bay	Ingham	Ingham	
Wisc. SR-6	135	209	244	144	65	290	234	267	199
Ohio MR-17	198	234	251	219	263	248	218	334	246
Ohio MR-25	220	—	—	184	—	—	198	244	—
Wisc. SMR-9	226	275	248	155	163	261	—	—	—
Wisc. SMR-12	230	215	270	185	182	308	280	333	250
Wisc. SMR-15								296	—
Wisc. SMR-18							269	352	—
Nappa 63							236	297	—
L.S.D. at 5 percent	66		NS	36	18	NS	32	56	
L.S.D. at 1 percent	NS		NS	49	27	NS	43	75	

Ohio MR-25 was unsatisfactory in these trials because it was consistently late in production. The other varieties tested matured evenly each year, with the exception of some experimental lines which produced several fruit per plant before the standard varieties came into production.

LENGTH/WIDTH RATIO

The L/W ratio is important to the processor because payment to the grower is based on the diameter of fruit. Glass containers for whole cucumbers are designed for a specific fruit shape. The ratio generally preferred by Michigan packers is approximately 2.6:1 with an acceptable range of 2.5:1 to 2.8:1.

Table 2 gives the L/W ratios of the commercially available varieties. With one exception, Ohio MR-17 had the highest L/W ratio at each location although the average ratio varied with location. Wis-

TABLE 2—L/W ratios of commercially available cucumber varieties, 1954-1957

L/W Ratio of fruits 1⅛ to 1½ inches in diameter

Variety	1954 (*a*)			1955 (*b*)			1956(*c*)	1957(*c*)	Av.
	Ingham	Berrien	Oceana	Ingham	Berrien	Bay	Ingham	Ingham	
Wisc. SR-6	2.3	2.6	2.6	2.6	2.7	2.8	2.5	2.2	2.54
Ohio MR-17	2.8	2.8	3.0	3.2	3.0	3.0	2.8	2.7	2.91
Ohio MR-25	—	—	—	2.7	—	—	2.6	2.6	—
Wisc. SMR-9	2.6	2.7	2.8	2.8	3.1	2.8	—	—	—
Wisc. SMR-12	—	—	—	—	2.8	2.9	2.6	2.6	—
Wisc. SMR-15								2.2	—
Wisc. SMR-18							2.8	2.7	—
Nappa 63							2.5	2.6	—
Average	2.6	2.7	2.8	2.8	2.9	2.9	2.6	2.5	

(*a*) Av. of 20 fruits at two harvests.
(*b*) Av. of 20 fruits at one harvest.
(*c*) Based on 10 fruits from each of 10 harvests.

consin SR-6 consistently had the lowest L/W ratio. The large variation in the L/W ratio of Wisconsin SR-6 is partially due to mosaic which causes a reduction in length of fruit.

Although the L/W ratios of varieties rank in approximately the same order, the averages for different years vary. The average L/W ratios also vary with harvest periods and locations, as shown in Table 3. The variation in L/W ratio from location to location is illustrated in Fig. 1, which compares salt stock of the variety MR-17 grown in Ingham and Montcalm Counties and harvested the same day. In a similar test in 1955, there were no significant differences in L/W ratios due to locations or dates of harvest.

*TABLE 3—The average L/W ratio of two harvests of six cucumber varieties grown at three locations in 1954**

Harvest date	County			
	Ingham	Berrien	Oceana	Average
August 11	2.53	2.68	2.70	2.64
September 7	2.50	2.61	2.85	2.65

*The F Value for the interaction of county and harvest date is significant at the 5 percent level.

Fig. 1. A comparison of salt stock of the variety Ohio MR-17 grown during 1954 in Ingham County above and Montcalm County below. The L/W ratios were 2.9 and 3.1 respectively.

QUALITY

Pressure tests were made on either the fresh cucumbers or salt stock or on both each year. The processor wants salt stock and fresh-pack pickles as firm as possible. When this quality is measured with the standard fruit pressure tester with 5/16-inch tip, a pressure reading of 14 pounds or higher is desirable.

A summary of these values is presented in Table 4. Of most interest is the low pressure reading for the variety Wisconsin SMR-12 compared with Wisconsin SR-6, Ohio MR-17, and Ohio MR-25. In addition, there is some variability in pressure readings made in different years, probably due to the salting procedure as well as to growing conditions.

In 1954, there was a difference in color of brined cucumbers from different locations. Fig. 2 shows the difference in color for Wisconsin SR-6 grown in Berrien and Oceana Counties and placed in the same brine tank for processing.

TABLE 4—Pressure tests of commercially available cucumber varieties, 1954-1957

Pressure tests (P.S.I. on 1⅛ to 1½ inches diameter fruit)

Variety	1954			1955 S(*a*)			1956 S(*b*)	1957 F(*b*)
	Ingham	Berrien	Oceana	Ingham	Berrien	Bay	Ingham	Ingham
Wisc. SR-6	22.9	20.1	20.3	15.4	16.2	15.9	14.3	17.0
Ohio MR-17	25.0	22.1	20.1	15.8	16.1	16.6	15.1	16.6
Ohio MR-25	—	—	—	14.8	—	—	15.8	16.5
Wisc. SMR-9	19.8	22.1	20.3	13.4	13.3	14.0	—	—
Wisc. SMR-12	—	—	—	13.8	13.5	13.5	13.2	15.3
Wisc. SMR-15								16.5
Wisc. SMR-18							14.8	16.9
Nappa 63							14.8	16.6

S = observations made on salt stock.
F = on fresh cucumbers.
(*a*) Based on 10 fruits from one harvest.
(*b*) Based on 10 fruits from each harvest.

Fig. 2. Salt stock of the variety SR-6 grown during 1954 in Berrien County (top), and Oceana County (bottom), harvested and placed in brine at the same time. Note the difference in color.

The fruit color of all varieties was usually lighter in early than in late pickings. Some showed this seasonal color change more than others. Wisconsin SMR-9 and SMR-12 fruits were so light for the first few harvests that some processors considered this a disadvantage for these varieties.

In 1955, samples from all of the varieties grown at East Lansing were processed as pasteurized fresh whole pickles.[4] In January of 1956, these samples were evaluated by a panel made up of four representatives of the cucumber processing industry. The results of this panel are presented in Table 5 along with the pressure tests of the samples.

TABLE 5—Evaluation of commercial varieties packed as pasteurized fresh whole pickles, 1956

Variety	Pressure test(*a*)	Panel rating(*b*)		
		Color(*c*)	Shape(*d*)	Acceptability(*d*)
Nat. Pickling	11.8	3.5	3.5	3.8
Wisc. SR-6	11.6	2.8	3.0	2.5
Ohio MR-17	13.4	2.5	2.2	2.5
Ohio MR-25	13.2	2.5	3.2	2.2
Wisc. SMR-9	10.5	2.8	2.0	2.0
Wisc. SMR-12	11.0	2.8	3.0	2.5
L.S.D. at 5 percent	1.0	NS	1.0	1.1
Coefficient of variation percent	10	23	23	28

(*a*) Average of 10 fruits under 1⅛ inches in diameter.
(*b*) Rating scale: 1—not acceptable, 2—poor, 3—fair, 4—good.
(*c*) Difference between judges significant at 5 percent level.
(*d*) No significant difference between judges.

The judges rated color, shape, and general acceptability of the different varieties. Although they agreed on shape and general acceptability, they differed significantly on most desirable color.

The former standard variety of pickling cucumbers, National Pickling, rated highest on both shape and general acceptability. A photograph of salt stock of this variety is presented in Fig. 3. National Pickling is no longer grown because of its susceptibility to scab and mosaic, but it appears to have the type and processing quality desired by Michigan processors. There were no differences among the other

[4]The assistance of I. J. Pflug of the department of agricultural engineering in processing these cucumbers is acknowledged.

Fig. 3. Salt stock of the variety National Pickling. This variety was rated highest by the judges for quality in a comparison of pasteurized fresh whole cucumbers.

varieties when compared for general acceptability; however, Ohio MR-25, Wisconsin SR-6, and SMR-12 were rated higher for shape than Wisconsin SMR-9.

Results of salt stock evaluation of samples from the 1957 trial are presented in Table 6. Samples were from five pickings placed in brine tanks between August 1 and August 19, and removed for judging on February 5, 1958. A panel of six judges rated the samples for color, shape, and acceptability. Wisconsin SMR-12 rated highest in all three, but was lowest in pressure test and produced a relatively high percentage of bloaters in the No. 3 fruits.

The new variety Wisconsin SMR-15, ranking in acceptability only slightly below SMR-12, produced fewer bloaters and a higher pressure

TABLE 6—Evaluation of salt stock samples of cucumber varieties, 1957

Variety	Average score (*a*)			Pressure test (*b*)	Bloaters pct.(*c*)
	Color	Shape	Acceptability		
Nappa 63	2.97	2.80	2.63	13.1	42.4
Wisc. SR-6	3.47	2.47	2.43	13.6	31.2
Wisc. SMR-18	2.87	2.90	2.63	14.5	16.4
MR-17	2.87	2.73	2.57	14.5	35.6
MR-25	2.60	2.77	2.47	14.3	17.6
SMR-12	3.67	3.00	2.90	12.3	29.5
Wisc. SMR-15	3.33	2.83	2.77	13.4	12.7
L.S.D. at 5 percent	.31	.26	.31	1.06	
L.S.D. at 1 percent	.41	.34	.41	1.42	

(*a*) Average of 5 replications × 6 judges = 30 ratings/4 = good, 3 = fair, 2 = poor, 1 = unacceptable.
(*b*) Fruit pressure tester $\frac{5}{16}$-inch tip, 10 No. 2 fruits from each rep.
(*c*) Based on approximately 50 No. 3 fruits.

test. The low color score for SMR-18, MR-17, and MR-25 is due to the general preference by Michigan processors for lighter colored fruits.

The low scores for SR-6 (Table 6) in shape and acceptability may be attributed to a rather high incidence of mosaic fruits. Fruit symptoms of mosaic also affected the ratings of Nappa 63. All but these two were relatively free of mosaic.

Although the bloating percentage was based on relatively small samples, the data in Table 6 indicate that Nappa 63, SR-6, MR-17, and SMR-12 might produce a relatively high percentage of bloaters, compared with SMR-15, MR-25, and SMR-18.

DISCUSSION

The decision a processor or grower must make regarding variety of cucumbers for pickles depends upon production, disease tolerance, and processing quality. In the latter, the choice is largely a matter of personal preference. For this reason, recommendations can not be made without some qualifying information regarding varietal characteristics so that growers and processors may choose varieties to suit their individual needs and preferences.

On the basis of 4 years' results, it appears that the most widely acceptable variety is Wisconsin SMR-12, because of its resistance to both scab and mosaic, satisfactory yield, and its fairly light color in salt stock which is preferred by most Michigan processors. Its principal defects are: 1) lack of firmness as measured by pressure test, 2) a tendency to develop nubs and crooks under adverse weather conditions, and 3) a tendency to develop bloaters in salt stock.

In areas where mosaic is not a factor, Wisconsin SR-6 would be recommended. Under mosaic-free conditions, its color is as good as Wisconsin SMR-12, its shape is generally better, and it has a higher pressure test. There is a distinct tendency toward bloaters in No. 3 size fruits from salt stock.

The new variety Nappa 63 produced lower yields than SMR-12, developed more mosaic fruits, and also showed a rather high incidence of bloaters. Quality in salt stock from the standpoint of color, shape, and acceptability was judged satisfactory. It should be given extensive trial, particularly in areas where mosaic is not severe.

Wisconsin SMR-18 very closely resembles Ohio MR-17 in color, shape, and quality. It has the advantage of scab resistance and is recommended as a replacement for Ohio MR-17 for growers who have

found the latter variety satisfactory. For most Michigan processors, both of these varieties are too long and too dark in color.

Another newly introduced variety, Wisconsin SMR-15, is worthy of extensive trial by processors. It has been rated better in color than Ohio MR-17 or Wisconsin SMR-18. It is superior to Wisconsin SMR-12 in firmness and produces few bloaters in salt stock. The principal disadvantage is its failure to produce yields as high as SMR-18 or SMR-12.

The other varieties included in one or more trials, National, Model, Wisconsin SMR-3, SMR-9, M.S.U. No. 1, and Ohio MR-25 are not recommended for production in Michigan because they lack disease tolerance, yielding capacity, or other important characteristics available in the varieties discussed above.

SUMMARY

Pickling cucumber varieties have been tested for yield and processing quality over a 4-year period in Michigan.

No variety is available that will suit the requirement of all Michigan processors. The choice of variety must depend largely upon the local disease situation and personal preference.

Among the varieties available commercially, the following appear to have some place in Michigan production: Wisconsin SMR-12, Wisconsin SMR-15, Wisconsin SMR-18, Wisconsin SR-6, and Nappa 63. Data are presented on yield and processing quality and recommendations are based on these data and observations.

The results of these experiments emphasize the need for further improvement in pickling cucumber varieties in Michigan.

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OPTIMUM LENGTH OF LAYING PERIOD AND TIMING OF LAYING FLOCK REPLACEMENT

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DEPARTMENT OF AGRICULTURAL ECONOMICS

HOW LONG should hens be kept in the laying flock and at what time of year should they be replaced in order to obtain the largest possible returns from the enterprise? The most common practice in the past has been to purchase the chicks for the replacement flock in the early spring. After the pullets begin to lay, they are usually kept until the time they enter "winter pause" or "molt." This system involves about a 12-month laying period with the replacement of the old hens taking place in the fall.

In recent years, a few poultrymen have been keeping their hens into the second laying year. Also, a few have been following a multiple hatching system where several batches of chicks are started at different times of the year. The longer laying period reduces the annual rate of laying flock replacement, thus, reducing the annual replacement costs. Also, keeping the hen into her second laying year yields a greater return for the investment made in raising the chick to laying age.

The multiple hatch system (pullets enter the laying flock at different times during the year) tends to smooth out extreme fluctuations in the volume of the various sizes of eggs produced over a period of a year. This system also makes the fullest use of the available poultry housing over the whole year.

How the level of egg production holds up into the second year of lay and the seasonal price pattern of the various sizes of eggs will largely determine whether or not such changes will result in increased returns. The purpose here is to consider how the question of optimum

ARTICLE 40-109

length of laying period and timing of replacement would be answered for a commercial laying enterprise. The seasonal price pattern of the various sizes of eggs and the pattern of egg production over the productive life of hens hatched at different times of the year are taken into account.

THE SITUATION STUDIED AND ASSUMPTIONS

The problem is to determine: 1) How many months the hens will be kept in the laying flock, 2) in which month or months chicks for the replacement flock will be purchased, and 3) how many chicks will be purchased in each batch to maximize the returns from the enterprise.

The situation studied here is one in which the producer has 10,000 square feet of poultry housing,[2] any part of which can be used for either raising replacement pullets or for housing the laying flock. Sexed Leghorn chicks are purchased from which the replacement pullets for the laying flock are raised. Chicks can be purchased on the first of any month.

Five months is considered the length of time required to raise the chicks to laying age. The minimum length of time that the hens would be kept in the laying flock is 7 months; the maximum length of time is 24 months. The length of the laying period may be any full number of months within these limits.

The size of the poultry house determines the number of birds that may be housed at any one time. Within this limitation on the size of the enterprise, wide variations in the length of time hens are kept and the time of year that they are replaced are possible.

In this case, 18 different lengths of laying periods are considered, ranging from 7 to 24 months, as well as 12 different dates for starting the replacement flock. This results in 216 (12 times 18) distinct alternatives with respect to length of laying period and timing of replacement. The best organization may be any one or a combination of these alternatives.

It is apparent that there are a great many ways in which the enterprise might be organized. In order to evaluate these possibilities, the following information is needed:

[2]This area was arbitrarily chosen. However, it was felt that this amount of housing would permit a maximum size of enterprise which one man could easily handle. Changes in the amount of housing that is available would simply result in proportional changes in the bird numbers.

1) Monthly price of:
   a. Chicks
   b. Eggs of various sizes
   c. Cull pullets and old hens
   d. Laying flock and replacement flock ration.

2) Production:
   a. Monthly production of small, medium, and large eggs over the productive life of the hen
   b. Mortality rate.

3) Inputs:
   a. Feed input for the laying flock
   b. Feed input for the replacement flock
   c. Floor space used per bird by the laying flock and by the replacement flock.

The costs associated with buildings and equipment have not been included in this list since a given set of buildings has been specified. These costs are the same, regardless of the type of organization that is followed, so they have no bearing on the choice of organization. The supply of labor has been assumed to be adequate so labor inputs have not been specifically taken into account.[3]

Since floor space is fixed at 10,000 square feet, the number of birds that can be housed at any one time is dependent upon the floor space used per bird per month. The floor space used per bird here is 1 square foot from hatching to 3 months of age, 2 square feet from 3 to 5 months, and 3 square feet[4] from 5 months on.

In order to estimate the egg production for the various lengths of laying period, mortality must be considered. The assumed normal mortality rate is 2 percent per month except in the first month following hatching, and in the fifth month just before the pullets enter the laying flock. The mortality rate in the first month was set at 5 percent and the decline in bird numbers at 10 percent in the fifth month. The latter takes into account culling the pullet flock in addition to normal mortality losses.

[3]On farms which have enterprises other than the laying enterprise, the omission of labor inputs from the analysis would be quite serious. The question then arises whether or not labor can be more profitably spent on some other than the laying enterprise in certain periods of the year. The situation here is one in which the laying enterprise is the only one and the feeds are all purchased so that all the labor can be used for the care and management of the laying flock.

[4]Three feet is the usual recommendation; however, many producers have been able to crowd their birds somewhat more closely without adversely affecting production to any great extent.

The feed requirement for the laying flock was estimated at 8 pounds per hen per month at a cost of $3.30 per cwt. It was estimated that 2,780[5] pounds of feed would be required to raise 100 chicks to laying age at a cost of $4.30 per cwt. The cost of chicks was assumed to be $32.35 per 100. The price for cull hens and pullets was $.12 per pound, assuming that the weight of a cull pullet is 4 pounds and a cull hen is 5 pounds.

The production of eggs in a flock and also the composition of the total production in terms of egg size will vary from month to month. The monthly pattern of egg production over a 24-month laying period assumed in this analysis is shown in Table 1 for hens coming from hatches at four different periods of the year. The estimates appearing in this table are based on results from experiments and numerous laying trials carried out in various sections of the country.

[5]This estimate allows for normal mortality over the growing period.

TABLE 1—Total egg production per bird per month (in dozens) (a)

Month of lay	Month hatched			
	Dec., Jan., Feb.	Mar., Apr., May	June, July, Aug.	Sept., Oct., Nov.
1	1.5	.5	1.0	1.5
2	1.6	1.1	1.6	1.6
3	1.6	1.6	1.8	1.7
4	1.5	1.6	1.7	1.7
5	1.3	1.6	1.6	1.6
6	1.1	1.6	1.6	1.6
7	1.1	1.6	1.5	1.5
8	1.1	1.6	1.4	1.3
9	1.3	1.5	1.3	1.1
10	1.5	1.4	1.2	.9
11	1.5	1.3	1.0	1.0
12	1.4	1.1	.8	1.0
13	1.3	.9	.7	1.2
14	1.3	.8	1.3	1.3
15	1.3	.6	1.5	1.4
16	1.3	.5	1.4	1.4
17	1.1	1.5	1.3	1.3
18	1.0	1.4	1.3	1.3
19	.8	1.4	1.3	1.2
20	.7	1.3	1.2	1.0
21	.7	1.3	1.1	.9
22	1.2	1.3	.9	.8
23	1.4	1.3	.8	.7
24	1.4	1.3	.7	1.0

(a)Estimates prepared by Richard Wheeler, department of agricultural economics, Michigan State University

However, it should be pointed out that only limited information was available on the pattern of egg production for the second 12-month laying period. Hence, the estimates for this portion of the laying period are less reliable. These estimates of total egg production were then broken down into an estimate of the production of small, medium, and large eggs in each month of lay.

The monthly prices of small, medium, and large eggs used in this analysis are shown in Fig. 1. These prices are the average monthly prices received for eggs on the Detroit market from 1953 through 1956.[6]

Estimates of the return over chick and feed costs per 100 hens at the start of the laying period, based on the above assumptions, have been made for each of the 216 alternatives that have been described. These alternatives were then compared using the technique of linear programming in arriving at the optimum organization of the laying enterprise.[7]

[6]These prices are taken to represent the general nature of the seasonal price relationships for eggs of various sizes. In any one year, the seasonal price pattern may differ considerably from the average that is shown here.

[7]For a detailed description of the way in which the analysis was carried out refer to Gervais, Michel A. (1957). Optimal utilization of limited floor space in a laying enterprise. Thesis for degree of M.S., Mich. State Univ., East Lansing. (Unpublished)

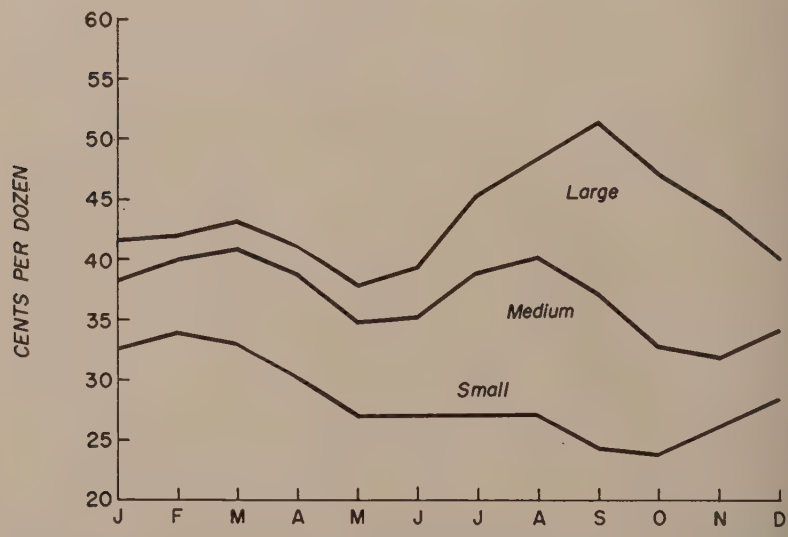

Fig. 1. Average monthly price of large, medium and small eggs—Detroit market 1953-1956.

THE RESULTS

The optimum organization of the laying enterprise under the assumptions that have been outlined is given in Table 2. The exact results are presented here to more clearly illustrate the relationships that are involved. Obviously, it would not be possible to specify bird numbers in actual practice as precisely as they are presented in this table and the tables that follow.

Table 2 shows the number of birds of various ages that would be housed in each of the 12 months of the year. In the month of June, there would be about 250 chicks in their first month in the replacement flock. The laying flock would consist of 175 hens from a June 1 hatch of the previous year, 275 hens from a July 1 hatch of the previous year, 875 from an August hatch, and 450 from a November hatch of the previous year. The total is about 1,800 hens about 1 year old.

In addition, there would be about 1,400 hens about 2 years old, 150 of which were hatched June 1, 2 years earlier, 200 from a July hatch, 700 from an August hatch, and 350 from a November hatch 2 years earlier. The total number of birds in the replacement flock would be 250 and the laying flock would be 3,200 hens in the month of June. The other columns in the table would be similarly interpreted.

The raising of replacement pullets extends from June through March in four separate batches varying in number from 250 chicks started in June to 1,200 started in August. The bulk of the replacement pullets are raised in the 6-month period from August through December.

The size of the laying flock varies from 2,150 hens in November to a maximum of 3,325 in April. The length of time that the hens are kept in the laying flock varies from 20 to 23 months. The return over chick and feed costs for this way of organizing the laying enterprise is estimated at $7,177.

The most important feature of this way of organizing the laying flock is the age composition of the flock over the course of the year. Concentrating the raising of the replacement pullets in the late summer and early fall months and keeping the hens in the laying flock about 22 months results in a pattern of egg production that takes full advantage of the seasonal price pattern of small, medium, and large eggs. Fig. 2 shows the monthly production of small, medium, and large eggs for this organization of the enterprise.

Pullets begin to enter the laying flock in November from the June

TABLE 2—Number of birds in the replacement flock and in the laying flock by months

Date of hatch	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Current year's hatch												
June	**257**(*a*)	**244**	**239**	**234**	**230**	207	203	199	195	191	187	183
July		**391**	**371**	**364**	**356**	**349**	314	308	302	296	290	284
August			**1,198**	**1,139**	**1,116**	**1,093**	**1,072**	964	945	926	908	890
November						**599**	**569**	**557**	**546**	**535**	482	472
Previous year's hatch												
June	179	176	172	169	165	162	159	156	153	150	146	143
July	278	273	267	262	257	252	247	242	237	232	228	223
August	872	854	837	820	804	788	772	757	742	727	712	698
November	463	453	444	435	427	418	410	402	394	386	378	371
Hatched 2 years earlier												
June	140	121										
July	219	214										
August	684	670	657	644	579	13						
November	363	356	349	342	335	328	322	118				
Total replacement flock	257	635	1,809	1,737	1,702	2,041	1,640	557	546	535	—	—
Total laying flock	3,198	3,118	2,727	2,672	2,567	2,168	2,426	3,145	2,966	2,907	3,331	3,263

(*a*) Those values in bold face refer to the replacement flock, all other values refer to the laying flock.

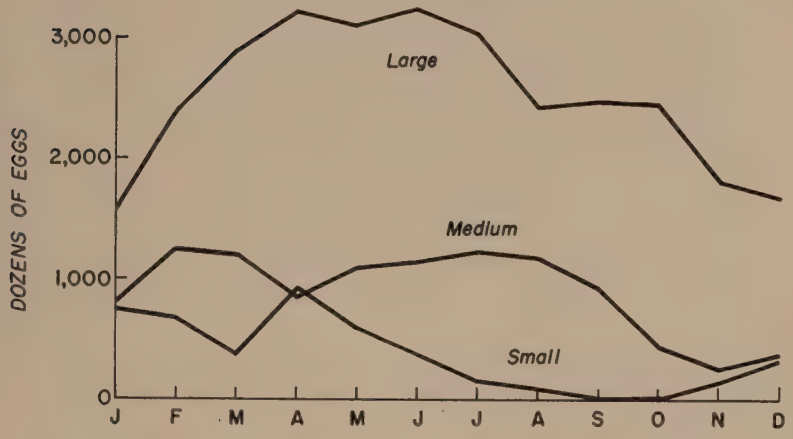

Fig. 2. Monthly production of large, medium and small eggs under the optimum organization.

hatch; and are added through April from the later hatches. Although these birds will produce mostly small eggs, they will do so during the winter and early spring, a time when small eggs would tend to be most favorably priced relative to the price of medium and large eggs, (see Fig. 1). In other words, the price discount on small eggs tends to be the smallest at this time of year.

The total production of the small eggs from the enterprise falls off as the pullets mature and the production of medium and large eggs increases. During the period from July through November when the discount on small eggs tends to be the greatest and the price of large eggs are usually at their seasonal high, the laying flock consists almost entirely of mature hens and the production will be mainly medium and large eggs.

However, the greatest volume of large eggs is not produced at this time because a considerable area of the poultry housing is being used for raising the replacement pullets. With this organization of the laying enterprise, the largest volume of large eggs is produced in the period from April through July. This covers a period of the year when the price of eggs is generally low.

To try to move the time for starting the replacement flock so that the peak in large egg production coincides with the peak in large egg price would result in selling the small eggs at a time when they are

being discounted more heavily. The resulting loss in income from selling the smaller eggs under the less favorable price conditions more than off-sets the gain in income from selling a greater volume of large eggs at the time when their price is the highest.

Another alternative might be to go to a shorter laying period in which the entire flock is replaced annually with the chicks for the replacement flock purchased in the early spring. However, this alternative would result in higher replacement costs which more than offset any income gains that might be achieved.

Several alternatives to the organization shown in Table 2 have been examined. The first is the same general type of organization as shown in Table 2, but with the hatching dates moved up 3 months so the peak in large egg production coincides with the peak in large egg prices. This modification would result in a return over chick and feed costs of $6,852. This return is $325 lower than the estimated return from the optimal organization.

The peak in small egg production would be in July at a time when the price discount has nearly reached its maximum. Peaks in medium egg production would occur in November and again in June, times when they are at their lowest prices.

One objection that might be raised to the type of organization shown in Table 2 is that the management is difficult because several different age groups are housed at the same time. This would mean keeping them penned separately. However, due to the number of birds involved in this size of enterprise, one would want to have separate pens of a few hundred birds anyway to minimize problems of cannibalism, feeder crowding, etc.

For comparison, a system in which a single hatch is started each year was examined as an alternative to the multiple hatch systems just described. The most profitable single hatch system would be one in which the chicks are started in July and the hens kept in the laying flock for 20 months. With 10,000 square feet of poultry house, one would have 1,700 pullets coming into lay in January. Under this system, the available housing would be fully utilized in the first months of the year, but in later months the house would be used to less than full capacity as flock size is reduced by mortality.

The return over chick and feed costs for this system would be $6,421 compared to $7,177 with the "optimum" organization; or a difference of $756.

TABLE 3—Monthly utilization of the available 10,000 square feet of floor space under the optimal organization

Date of hatch	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Current year's hatch												
June	**257**(*a*)	**244**	**239**	**468**	**460**	621	609	597	585	573	561	549
July		**391**	**371**	**364**	**712**	**698**	942	924	906	888	870	852
August			**1,198**	**1,139**	**1,116**	**2,186**	**2,144**	2,892	2,835	2,778	2,724	2,670
November						**599**	**569**	**557**	**1,092**	**1,070**	1,446	1,416
Previous year's hatch												
June	537	528	516	507	495	486	477	468	459	450	438	429
July	834	819	801	786	771	756	741	726	711	696	684	669
August	2,616	2,562	2,511	2,460	2,412	2,364	2,316	2,271	2,226	2,181	2,136	2,094
November	1,389	1,359	1,332	1,305	1,281	1,254	1,230	1,206	1,182	1,158	1,134	1,113
Hatched 2 years earlier												
June	420	363										
July	657	642										
August	2,052	2,010	1,971	1,932	1,737	39						
November	1,089	1,068	1,047	1,026	1,005	984	966	354				
Area used by replacements	257	635	1,808	1,971	2,288	3,483	2,713	557	1,092	1,070	—	—
Area used by layers	9,594	9,365	8,192	8,029	7,712	6,517	7,287	9,453	8,908	8,724	10,000	9,792
Total area used	9,851	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	9,794	10,000	9,792

(*a*) Those values in bold face refer to the replacement flock, all other values refer to the laying flock.

Monthly utilization of the 10,000 square feet of poultry housing with the "optimum" organization is shown in Table 3. This table shows by months the area used by each age group, the area allocated to raising the replacement flock, the area allocated to the laying flock, and the total area of available housing used. As can be seen from the last line in the table, the house is filled to capacity in all months except March, May, and June.

In March there are about 200 square feet of floor space unused, in May about 200 square feet, and in June about 150 square feet. These amounts of floor space are relatively small and for all practical purposes one might regard the poultry house as being full to capacity throughout the entire year.

The point here is that in 9 out of the 12 months, the available area of floor space did limit the size of the enterprise and, hence, limit the amount of income that could be realized. Therefore, additional floor space in each of these 9 months would be of some value in terms of added income.

The technique of analysis used in this study provides estimates of the value of additional floor space in each month. These estimates are given in Table 4. Obtaining more floor space by adding buildings would add floor space in all 12 months and, hence, the enterprise as a whole would simply be enlarged leaving the type organization unchanged.

Another way of acquiring additional floor space in a particular month, would be to crowd the birds into a smaller area during that

TABLE 4—Value per month of an additional 1,000 square feet of floor space

Month	Value per 1,000 square feet
January	$ 31
February	127
March	0
April	194
May	0
June	0
July	57
August	75
September	96
October	44
November	23
December	71

period. Hence, these estimates of the value of additional floor space may be interpreted as estimates of the increase in returns to be obtained by using the floor space more intensively, providing a smaller square footage per bird, during a month.[5]

Additional floor space in the months of March, May, and June has no value since the house is not filled to capacity in these months with the "optimum" organization. Expanding the enterprise by crowding the birds in these months is not possible because the size of the enterprise is limited by the fact the floor space is used to capacity in the other 9 months. Any reorganization of the enterprise to utilize the total floor area in March, May, and June without crowding in the other months, would result in a lower return.

The largest effect on income would be achieved by crowding the flock in April. An additional 1,000 square feet of floor space in this month would increase income by $194. The use of this additional area would require some reorganization of the laying flock. This would necessitate readjusting the bird numbers in each of the age groups.

In April the house is filled to capacity with laying hens allowing them 3 square feet per bird. If the additional 1,000 square feet were obtained by crowding the present 3,325 hens into 9,000 square feet, the square footage per hen would be reduced to 2.7 square feet. Reducing the area of floor space per bird may have an adverse effect upon the level of egg production per hen. As long as the lowering of production per bird does not completely offset the increase in total production, however, it will pay to crowd the birds.

Estimates of the effect of crowding on egg production per bird were not obtained for this analysis. Hence, the effect on income and organization of using less floor area per bird was not fully investigated. The estimates in Table 4 are presented to suggest the possible effect on income of using the available floor space more intensively in certain periods of the year. From the estimates in Table 4, it appears that one might well consider crowding the birds somewhat in the months of February, April and September. It is in these 3 months that limited floor space is most crucial. The value of additional floor for each of the three months is $127, $194 and $96 per 1,000 square feet respectively.

This estimate does not take into account any effect on production per hen from concentrating a greater number of birds in a given area.

[5]Provided that the production per bird does not change.

The limited floor space is considerably less restricting income-wise in the other months of the year as evidenced by the lower estimates of the value of additional floor space in these months.

SUMMARY

Under the conditions that have been assumed in this analysis, an organization of the laying enterprise which spreads the raising of the replacement pullets over the year in four separate batches and keeps hens in the laying flock about 22 months is the most profitable. In this organization, the raising of the pullets is concentrated in the late summer and early winter months in order to have the pullets enter the laying flock at a time when small eggs are most favorably priced relative to medium and large eggs.

By starting the replacement flock in a series of separate batches, the poultry house is more nearly utilized to full capacity throughout the entire year and the pattern of egg production is less subject to wide fluctuations.

Finally, with long laying periods, the investment in hens is more fully exploited and the annual rate of replacement is reduced, thus lowering the annual cost associated with the raising of the replacement flock.

One final word, the optimum organization of the laying enterprise is dependent upon a number of different factors. For example, the development of strains of chickens capable of a sustained level of production over a long period of time would tend to cause longer laying periods to be included in the optimal organization that has been developed.

Movement of the seasonal price pattern to the right or left would alter the optimum timing of laying flock replacement. Therefore, the organization of the laying enterprise must be re-evaluated from time to time in light of the changes that may be taking place in the various determining factors.

MULTIPLE PURPOSE TANKS FOR MICHIGAN CHERRY GROWERS

By J. H. LEVIN and C. M. HANSEN[1]

U. S. Department of Agriculture and Department of Agricultural Engineering

During each of the past 3 years, Michigan packers have moved annually more than 25,000,000 pounds of cherries from receiving stations to processing plants in packer-owned tank trucks.

It has been demonstrated that, when 50 tons or more are handled, producers as well as packers can use the water method to advantage.[2] During the 1957 season, the fruit produced by several of Michigan's largest cherry growers moved to receiving stations or to processing plants in grower-owned tank trucks.

There are many other growers who would like to use the water method. However, they have not been able to do so because their operations are not large enough to justify the purchase of a tank that is used only during the relatively short harvest season. Fortunately, for these producers, there are several other cherry growing operations in which tanks can often be used to advantage.

Often nitrogen fertilizer can be applied more easily, quickly, and effectively in liquid form than in the dry state. A producer who has a suitable tank is in a position to use this newly-developed method.

Tank equipment can sometimes be used to advantage in hauling water to sprayers that are being operated in blocks of trees located at some distance from a source of water.

A mobile tank may also prove useful in hauling water to young plantings that are suffering from drought.

It was suggested that a multiple-purpose unit would be more practical for growers than single-purpose tanks.

[1]The authors wish to express their appreciation to Tryco Manufacturing Co., Decatur, Illinois for the loan of the equipment used in this research. Also to H. P. Gaston, department of horticulture, who gave substantial help in carrying on this project.

[2]Gaston, H. P., and J. H. Levin (1955). Transporting red cherries in water from orchard to processing plant. Mich. Agr. Expt. Sta. Quart. Bul. 37: 437-443 Levin, J. H., and H. P. Gaston (1956), Grower handling of red cherries. U.S.D.A. Circ. No. 981. 20 pp.

ARTICLE 40-110

A multiple-purpose tank was designed and a manufacturer constructed an experimental tank. It was made available for trial during the 1957 season.

THE EXPERIMENTAL TANK

The tank was mounted transversely to the axle on a two-wheel trailer with a 50-inch tread. The tires used were 700 by 16—6 ply. The tank was 61 inches long and 38 inches in diameter, and had a capacity of about 300 gallons (Fig. 1).

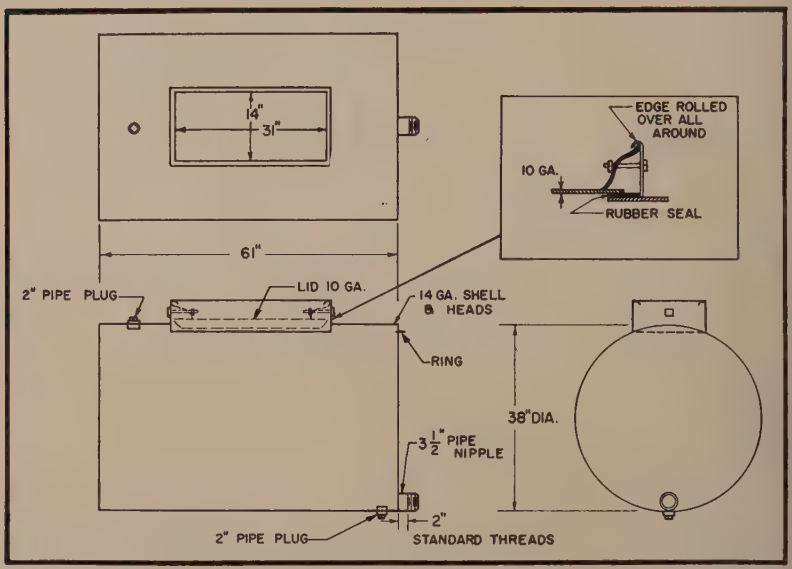

Fig. 1. A drawing of the 300 gallon experimental tank.

Two-inch threaded openings were provided in the top and bottom of the tank to facilitate the handling of liquid fertilizers and water. A 3½-inch opening, located at the bottom of the rear end (see Fig. 1), was fitted with a threaded nipple. When the tank was being used for fertilizer or water, the nipple was capped. When the unit was being used for cherries, the cap was removed during the time fruit was being flumed out.

During part of the trials, the nipple was fitted with a 4-foot length of heavy canvas hose. The open end of the hose was fitted with a hook so it could be snapped to a ring located at the top of the tank to hold it in an upright position. The cherries were flumed out by lowering the hose to the level of the outlet.

A 14- by 31-inch opening in the top of the tank was fitted with a cover, as indicated in Fig. 1. This opening was sealed except during the cherry harvest when the cover was removed and the opening used in loading. For other uses of the tank, this opening was sealed.

A sliding-vane pump driven by a 3½-HP gasoline engine was used in forcing the liquid fertilizer through the six nozzles located at the rear of the machine. The arrangement and design of the nozzles made it possible to vary the pattern of application. Fertilizer could be applied to the entire orchard floor or placed in bands at the drip of the tree.

Half of the inside surface of the tank was treated with a rust resistant coating. A different protective material was used on the other half.[3]

[3]Rustoleum chemical resistant coating #402 black and Minnesota-Mining and Milling-BC-776 slush coat adhesive.

Fig. 2. Here the experimental tank is being filled with cherries in the orchard. The cherries are in the cold water within an hour after removal from the tree. The picking lug never leaves the picker's hands.

THE TANK WAS TRIED

The experimental unit was used successfully in applying liquid fertilizer under commercial orchard conditions. When the fertilizer applications had been completed, the engine and auxiliary pump were disconnected, taken off the chassis, and set aside. The tank was then thoroughly cleaned and stored until harvest time.

When picking started, the tank was taken to a cherry receiving station, partially filled (to one-fourth of its capacity) with cold water, weighed and moved to a nearby orchard. The pickers added cherries to the tank until it was full.

The unit was then moved to the receiving station where it was re-weighed and the weight of the cherries it contained calculated. Then the cherries were flumed (through the 3½-inch outlet) into a transport tanker or storage tank. The tank was partially filled with water as before and returned to the orchard.

In actual trials, the fruit was moved from an orchard to a receiving station. It could have been used just as effectively in moving fruit to an orchard loading dock or to a nearby processing plant.

Fig. 3. These cherries are being flumed out of the tank at the receiving station. Notice that the hose is not attached to the outlet. The tractor or truck driver does all the work of unloading the cherries. He removes the cap, turns water into the tank, and watches the cherries flow out.

RESULTS

When used in connection with the harvest operation, getting the cherries into cold water quickly helped to maintain their quality. Using the tank reduced the amount of labor required to unload at the receiving station and replaced approximately 200 lugs. The unit, which had a capacity of about 2,000 pounds of cherries was emptied in from 9 to 10 minutes.

The experimental tank proved to be an effective means of applying the liquid fertilizer.

The protective coatings applied to the inside of the tank at the factory prevented chemical action between the tank and the cherries and made the tank easy to clean.

The grower, in whose orchard the trials were conducted, was pleased with the results obtained.

A NEW METHOD FOR PRODUCING HYBRID CUCUMBER SEED

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MANY PLANT BREEDERS HAVE USED hybrid vigor to improve field and horticultural crops. Corn is the classic example; increases of at least 20 percent in yield, greater uniformity of type and maturity, disease resistance, and improved quality have resulted from the development and use of hybrids.

Hybrid vigor in the cucumber was first reported by Hayes and Jones (1916) who found increased vigor in the F_1 to be manifest in size as well as number of fruits per plant. However, little or no heterosis was evident when parent varieties closely resembled each other. These results were confirmed by Hutchins (1938) and Lindsay (1944).

Graham (1952) and Weigle (1956) were not able to demonstrate significant yield advantages for hybrids from crosses of pickling varieties. Weigle (1956) suggested that the failure of hybrids to yield more than their parents could be attributed to a lack of genetic diversity in the pickling cucumber varieties used in his crosses.

Hybrids of slicing cucumbers have been used on a limited scale for several years. Their superiority over standard open-pollinated varieties is so great growers often pay from 10 to 20 times as much for hybrid as for open-pollinated seed.

Hybrid pickling cucumbers have received little attention because cost of seed produced by hand pollination would be too high. However, the advantages for hybrid pickling cucumbers should equal those for slicing types. If hybrids are to come into general use it will be necessary to develop seed production methods less costly than hand pollination.

Methods of hybrid seed production in general use are: (1) emasculation by removal of staminate (pollen bearing) flowers as in corn;

ARTICLE 40-111

(2) genetic pollen-sterile lines used as female (seed) parents in the case of onions, beets, corn, sorghum, and petunia; (3) use of self incompatible parents in the *Brassicas,* particularly cabbage; and (4) hand pollination of crops which produce relatively large numbers of seed per pollination and require few seeds per acre as tomatoes, squash, watermelon, muskmelon, and cucumber. A new method proposed here for production of hybrid cucumber seed involves the use of gynomonoecious lines as female parents.

EXPERIMENTAL

In 1954, we secured seed of the reportedly gynomonoecious[1] Korean variety, Shogoin (PI 220860) from the Regional Plant Introduction Station at Geneva, New York. Three greenhouse-grown gynecious segregates of Shogoin were crossed to a pickling cucumber selection, Wisconsin 18-7,[2] and F_1 seed was planted in the field.

Gynecious segregates which occurred in the F_1 were backcrossed to pickling type parents. Backcrossing was continued in the greenhouse and field until four backcrosses had been made. Crosses of gynecious x monoecious plants were also made within the Shogoin variety.

The incidence of gynecious plants in the F_1, BC_1, BC_2, BC_1 selfed, and BC_2 sibbed generations are given in Table 1. The BC_2 data suggest that it might be difficult to retain the gynecious character with continued backcrossing to the monoecious parent.

However, many of the plants classified here as monoecious showed a much stronger female tendency than the recurrent parent. In these so-called predominantly female plants, the female nodes outnumbered male nodes by ratios of 3 or 4 to 1, a sharp departure from normal monoecious in which the reverse ratio prevails. In most cases the predominantly female bore all its staminate flowers in the first 4 to 8 nodes.

When two such plants were sibbed in BC_2 (Lot 11, Table 1), the resulting progeny segregated 33 monoecious : 18 gynecious. Selfed predominantly female plants produced ratios of monoecious : gyne-

[1]The term gynomonoecious is used here to describe a variety or breeding line that produces two kinds of plants; gynecious in which all flowers are female and monoecious in which male and female flowers are born separately on the same plant. When used to describe individual plants, the term refers to those producing both female and bisexual flowers, a type of sex expression which has not been observed in cucumbers.

[2]The cooperation of J. C. Walker, University of Wisconsin, who provided seed of experimental lines for trial and breeding purposes, is gratefully acknowledged.

TABLE 1—Incidence of monoecious and gynecious plants in pickling cucumber breeding lines

Lot	Parents(*a*)	Generation	Flowering habit	
			Monoecious	Gynecious
1	Shogoin G x Shogoin M.....	Sib_1.....	11	5
2	Shogoin G x Wisc. 18-7 M....	F_1.....	8	3
3	Shogoin G x Wisc. 18-7 M....	BC_1.....	176	1
4	Shogoin G x Wisc. 18-7 M....	BC_2.....	122	0
5	Shogoin G x Wisc. 18-7 M....	BC_2.....	123	0
6	Shogoin G x Wisc. 18-7 M....	BC_2.....	223	0
7	Shogoin G x Wisc. 18-7 M....	BC_1 selfed.....	15	10
8	Shogoin G x Wisc. 18-7 M....	BC_1 selfed.....	21	3
9	Shogoin G x Wisc. 18-7 M....	BC_1 selfed.....	20	6
10	Shogoin G x Wisc. 18-7 M....	BC_1 selfed.....	18	5
11	Shogoin G x Wisc. 18-7 M....	BC_2 sibbed.....	33	18

(*a*) M = Monoecious.
G = Gynecious.

cious ranging from 15:10 to 21:3 (Lots 7-10, Table 1). The totals for four progenies were 74:24.

In these early generations the intermediate types were not classified, but a wide range of sex expression from strongly male to completely female was noted. Many plants classified gynecious at about the 10-node stage under field conditions produced only pistillate flowers through the entire growing season. A field-grown gynecious plant is illustrated in Fig. 1.

Because fewer clearly gynecious plants occurred as backcrossing proceeded, sib pollinations were made between gynecious and predominantly female plants in each backcross generation. In BC_1, six predominantly female plants were selfed. The resulting progenies

Fig. 1. A field-grown gynecious plant with leaves removed. At this stage, 23 successive female nodes were visible on the main stem and 11 on the lateral without a staminate flower being produced.

were planted in 1956 as female parents in a small isolation block with Ohio MR-25 as the pollen parent.

Monoecious and predominantly female plants in the six seed parent lines were rogued at about the 10-node stage, leaving the gynecious plants to produce hybrid seed. The percentage of gynecious segregates in these progenies ranged from 18.0 to 46.1 and averaged 42.0. The monoecious rogues were not classified with regard to flowering habit, but it was observed that at the first rogueing (10-node stage), many of the discarded plants showed a strong female tendency.

At subsequent inspections through the growing season approximately 18 percent of the remaining plants were removed because they developed one or two staminate flowers. The gynecious plants produced two or three ripe fruits per plant and seed production was excellent. Hybrid seed can be produced by this method at a small fraction of the cost of hand pollination.

To determine the effects of different environmental conditions on sex expression in gynomonoecious breeding lines, 10 such lines were planted at Ft. Collins, Colorado, and East Lansing, Michigan. Plants were classified according to flowering habit. All lines segregated

TABLE 2—Classification of gynomonoecious cucumber lines grown at Ft. Collins, Colorado, and East Lansing, Michigan, 1957

Line number	Colorado			Michigan		
	Flowering habit (*a*)			Flowering habit		
	M	PF	G	M	PF	G
	(percent)			(percent)		
151	35.5	35.5	29.0	26.3	26.3	47.4
153	19.0	57.1	23.8	20.0	35.0	45.0
155	34.5	55.2	10.3	18.4	42.1	39.4
156	25.0	45.0	30.0	22.2	22.2	55.6
173	30.0	30.0	40.0	32.5	10.0	57.5
174	35.2	41.2	23.5	25.7	20.0	54.2
178	22.2	44.4	33.3	18.9	10.8	70.3
182	42.1	31.6	26.3	47.0	38.2	14.7
184	8.0	48.0	44.0	40.0	17.1	42.9
190	22.2	38.9	38.9	20.5	7.6	71.8
Totals	27.5	43.1	29.4	26.6	23.7	49.7

(*a*) M = monoecious.
PF = predominately female.
G = gynecious.

gynecious plants at both locations, but the degree of female expression was affected by environment as indicated in Table 2.

The percentage of normal monoecious plants was changed very little in most lines. The average was 27.5 percent monoecious in Colorado compared with 26.6 percent in Michigan (Table 2).

The greatest difference between the two locations was in the incidence of gynecious and intermediate plants. Only 29.4 percent of the total population in the Colorado plots were gynecious compared with 49.7 percent in Michigan. There was a corresponding increase in the number of predominantly female plants under Colorado conditions.

DISCUSSION

The gynecious flowering habit can be incorporated into cucumber lines and such lines can be used to produce hybrid seed. The intensity of female expressions is influenced by environment and probably by genetic modifiers. Inherent differences in sex expression in strains of cucumber were reported by Tiedgens (1928) and Ito and Kato (1953).

Kumazawa, et al., (1955) reported the development of a cucumber variety that produced fruit at more than 80 percent of the nodes and was insensitive to day length and temperature. No description of gynomonoecious lines such as those used in this study has been published, and there are no reports on the inheritance of this type of sex expression.

It is well known that sex expression in cucumber is subject to changes caused by environment. An increase of pistillate flowers under short days and low light intensity was reported by Tiedgens (1928) and later confirmed by the work of Edmond (1930) and Nitsch, et al., (1952). The stability of the gynecious character was demonstrated when a high percentage of plants remained completely female under field conditions in such widely different environments as those encountered at East Lansing, Michigan, and Fort Collins, Colorado.

The occurrence of a higher percentage of predominantly females and fewer gynecious plants in Colorado may mean that it will be more difficult to rogue in some areas than others. The typical predominantly female plant, however, produces only one to four staminate flowers in most instances. These are borne either on early nodes where they can be identified and removed before pistillate flowers appear, or they are produced on late nodes after most of the fruit has been set on the gynecious plants.

In the proposed type of seed production plot, there is such a preponderance of pollen available from the male parent that it is unlikely that self and sib pollinations on the female parent line would occur frequently enough to be of any consequence. Furthermore, the female line used in commercial hybrid seed production probably would have good fruit type so that a low percentage of selfing and sibbing would be acceptable.

SUMMARY

Gynomonoecious cucumber lines, segregating gynecious plants under widely different environmental conditions, have been developed and used in production of F_1 hybrid seed. Under conditions at Fort Collins, Colorado, these lines produced fewer gynecious plants than at East Lansing, Michigan. The incidence of gynecious plants was high enough in both locations to make hybrid seed production practical.

To produce hybrid seed the gynomonoecious line used as the female parent was planted adjacent to a selected monoecious variety. At about the 10-node stage, all monoecious and intermediate plants were removed from the gynomonoecious line leaving gynecious plants to bear hybrid seed.

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DEEP PLOWING — A PROGRESS REPORT

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HISTORICALLY, PLOWING for seedbed preparation has been necessary for a number of reasons; namely, to loosen the soil, to destroy weeds, to dispose of trash and crop residues, and to break up sod. In the past, the depth of plowing has been governed by the power readily available on the farms. It is now possible for the farmer to plow to depths greater than 10 or 12 inches.

Plowing to depths greater than 10 to 12 inches represents another method of altering the structure of a soil. Further soil structure changes may be realized by using organic materials, fertilizers, and lime. It is also possible to bury weed and disease infested top soil by inverting the plow layer to greater depths.

Work was initiated in the fall of 1956 to explore the effects of these treatments on crop yields. A determination of the power requirements to plow soil to these greater depths was also included in this research.

Description of Plow

A plow having four 38-inch diameter disks was the basic tool used (Fig. 1). Two belt-type fertilizer hoppers were mounted parallel to the plow beam.

Provisions were made to use either two or four of the disks depending on soil conditions or the kind of tillage desired. When it was necessary to place the top layer of soil on the bottom of the furrow, the first and third disks were removed and conventional 14-inch moldboard plow bottoms mounted in their places (Fig. 2).

For operation on mineral soils, the rubber-tired rear furrow

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The authors wish to express their appreciation to Howard Haynes, Caterpillar Tractor Co., Peoria, Illinois for the assistance in carrying out the research reported in the paper and to Towner Manufacturing Co., Santa Ana, California for the loan of equipment.

ARTICLE 40-112

Fig. 1. The giant disk plow in operation in a shallow layer of muck soil, fall, 1957. The clay sub-soil is being mixed with the muck. The hopper belts are powered by the land wheel.

Fig. 2. View of giant disk plow before hoppers were mounted on frame. Two large disks were replaced with moldboard plows.

wheel which worked satisfactorily on organic soils, had to be replaced with a weighted steel wheel. This was done to counteract the great side draft that occurred while plowing.

PROCEDURE

The first phase of the deep plowing research was conducted on mineral soils where test strips were plowed in farmers' fields. Such exploratory work was necessary to become acquainted with the plow and to observe its action on fine-textured, compact soils such as the Sims and Parkhill soil series. In each field, areas were plowed in September 1956, when the soil was relatively dry, to a depth of 24 to 26 inches. The plow was adjusted so that maximum mixing of the surface soil to the depth of the cut was obtained. This was done so the top layer of soil could be used as a soil conditioner.

On one part of the field, fertilizer was placed in bands on the bottom of the furrow at the rate of 1,000 pounds of 0-40-20 per acre. Another part of the field received no fertilizer, but was plowed to a depth of 24 inches. These two treatments were compared with the conventional plowing of a moldboard plow. Subsequent tillage was the same on all areas. In the field which was planted to corn, a third treatment was made in which a disk harrow was the only tool used to prepare the seedbed.

Corn was grown on the Huron County plots and sugar beets on those located in Tuscola County. Both crops were given a planting time application of fertilizer of a recommended grade and rate.

The second phase of the research included the use of organic material and fertilizer as soil amendments. These experiments were located in Ingham and Calhoun Counties where previous research showed that sub-soiling gave increased corn yields.

Alfalfa, sawdust, wheat straw, and crop residue were the organic materials used. They were either plowed down to a depth of 9 inches with the moldboard plow or to 18 inches with the giant disk plow. A second crop residue area was sub-soiled to a depth of 26 inches transversely to the direction of plowing before plowing. The sub-soiler passes were 50 inches apart.

Each of the plowed areas in the second phase were sub-divided into three parts. One did not receive plow down fertilizer. Fertilizer at the rate of 500 and 1,000 pounds per acre was applied before plowing to the second and third areas respectively. A 12-12-12 fertilizer

was used on the Kalamazoo sandy loam (Calhoun County) experiment and 5-20-10 was used on the Conover loam (Ingham County). A planting time application of 500 pounds of the respective grades was used on all plots.

The third phase of the research deals with the use of lime on a weedy-acid Rifle peat, having a pH of 5.2. This experiment was located in Lapeer County. The disks were adjusted so that sub-soil from the bottom of the furrow would be deposited on the surface and the surface soil buried on the bottom of the furrow. Lime was applied with the application hoppers and plowed down at the rate of 3 tons per acre. On a second area, lime was applied at the same rate to the surface of soil and mixed into the soil with a disk harrow. Check areas received the same tillage treatments without the lime. The four areas were planted to head lettuce, Cornell 456, in 1957.

RESULTS

Power required to pull the giant plow varied with soil types and with the physical status within a given type. Two crawler-type tractors having a combined draft of 10,400 pounds and traveling at a rate of 2.64 miles per hour were required to pull two 38-inch disks to a depth of 22 inches in the organic soil in Lapeer County. The width of cut of the two disks was 26 inches. The power requirements for the two disks in the mineral soil were somewhat less, 9,976 pounds at 1.81 miles per hour.

In both of these cases, the moldboard jointers were not used largely due to lack of sufficient tractor power. Accurate information as to power needed when the four disks were used in mineral soil is not available. It was found that a crawler tractor having a draft of about 12,000 pounds at 2.6 miles per hour was sufficient.

The effect of the supplemental deeply placed fertilizer and deep plowing on crop yields taken from the Huron and Tuscola County plots is shown in Table 1. Deep plowing without the use of supplemental fertilizer had no effect on sugar beet yields. This is in agreement with previously reported data.[2] The corn yields were increased by deep plowing almost 12 percent to over 100 bushels per acre. Supplemental fertilizer placed in the bottom of the furrow on the deep-plowed plots, increased sugar beet yields 3.6 tons per acre, but did not significantly affect corn yields (Table 1).

[2]Cook, R. L., J. F. Davis, M. G. Frakes, G. E. Nichol and P. A. Reeve (1957). Fertilizers for sugar beets. Mich. Agr. Expt. Sta. Quart. Bul. 39 (3): 524-535.

TABLE 1—The effect of deep plowing and supplemental fertilizer on corn and sugar beet yields

Treatment:	Corn Bu./A.	Sugar beets T./A.
Moldboard plow—9-inch depth	87.2	22.1
Giant disk plow (*a*)—24 to 26-inch depth	101.2	22.8
Giant disk plow+1,000 lb. per acre 0-40-20 in plow furrow	106.3	25.7
Disk harrow only	94.9	....

(*a*) Thirty-eight inch diameter disk.

Crop yield data on the second phase of research are recorded in Table 2.

On the Kalamazoo sandy loam soil, one of the more droughty agricultural soils of southern Michigan, fertilizer applied with the plow did not significantly affect yields. Yields from the deep-plowed plots average 7.5 bushels per acre more than those from the conventional tillage plots. Sub-soiling did not affect crop yields. Sawdust amendments depressed yields slightly, while alfalfa increased yields by about 11 bushels per acre.

On the Conover loam soil, planting was delayed several days because water had collected in the sub-soiled and deep plowed areas. The lack of sufficient drainage made it necessary to discard one replication of the treatments. An excess of surface water during the early part of the growing season seriously retarded growth of corn.

In this experiment, organic matter, regardless of source, had no effect upon corn yields. Also depth of plowing and sub-soil treatments did not significantly affect corn yields. Commercial fertilizer placed in the sub-soil increased yields about 5 bushels per acre. This increase was statistically significant, but not great enough to pay for the extra fertilizer and tillage involved in these treatments. In this experiment there was a significant interaction between plowing depth and fertilizer rate.

The third phase data taken from the organic soil plots in Lapeer County showed that no yield increases were obtained as a result of the use of lime or deep plowing. Yield increases due to the use of lime were not anticipated because the original soil pH was 5.2. This is adequate for lettuce. There was a marked reduction in weed population and subsequent labor required to control weeds in the area where the giant disk plow was used.

TABLE 2—The effect of deep plowing and supplemental fertilizer and organic matter on corn yields

Treatment(*a*)	Type of plow	Plow depth, inches	Pounds per acre of fertilizer(*b*) plowed down	Yield—Bu./A.	
				Kalamazoo sandy loam	Conover loam
Alfalfa	Disk(*c*)	18	0	71.2	67.9
Alfalfa	Disk(*c*)	18	500	71.5	77.4
Alfalfa	Disk(*c*)	18	1,000	72.0	78.0
Alfalfa	Moldboard(*d*)	9	0	60.7	66.7
Alfalfa	Moldboard(*d*)	9	500	64.4	65.6
Alfalfa	Moldboard(*d*)	9	1,000	64.1	61.8
Sawdust	Disk(*c*)	18	0	56.2	59.4
Sawdust	Disk(*c*)	18	500	58.2	73.7
Sawdust	Disk(*c*)	18	1,000	57.4	70.1
Sawdust	Moldboard(*d*)	9	0	40.1	67.4
Sawdust	Moldboard(*d*)	9	500	45.8	67.5
Sawdust	Moldboard(*d*)	9	1,000	47.7	63.6
Wheat straw	Disk(*c*)	18	0	....	55.1
Wheat straw	Disk(*c*)	18	500	....	70.4
Wheat straw	Disk(*c*)	18	1,000	....	71.0
Wheat straw	Moldboard(*d*)	9	0	....	72.4
Wheat straw	Moldboard(*d*)	9	500	....	77.3
Wheat straw	Moldboard(*d*)	9	1,000	....	62.9
Crop residue	Disc(*c*)	18	0	54.5	71.1
Crop residue	Disc(*c*)	18	500	57.1	78.5
Crop residue	Disc(*c*)	18	1,000	54.2	75.3
Crop residue	Moldboard(*d*)	9	0	46.0	65.8
Crop residue	Moldboard(*d*)	9	500	52.3	72.1
Crop residue	Moldboard(*d*)	9	1,000	51.1	67.8
Sub-soiled	Disc(*c*)	18	0	60.2	55.5
Sub-soiled	Disc(*c*)	18	500	54.8	56.6
Sub-soiled	Disc(*c*)	18	1,000	54.8	78.0
Sub-soiled	Moldboard(*d*)	9	0	53.1	67.6
Sub-soiled	Moldboard(*d*)	9	500	54.2	67.6
Sub-soiled	Moldboard(*d*)	9	1,000	51.7	73.1

(*a*) Organic matter applied at rate of 5 tons per acre.
(*b*) Pounds per acre, 12-12-12 on Kalamazoo and 5-20-10 on Conover.
(*c*) Thirty-eight inch disk plow.
(*d*) Standard moldboard plow.

SUMMARY

This report includes a description of a giant disk plow and a discussion of the first year's results obtained with this implement. Deep plowing may be feasible where soil structure is a problem, or where it is necessary to place such amendments as fertilizer, organic matter, or lime in the sub-soil.

In addition, it may be practical to bury weed- and disease-infested top soil, so that seeds can be planted in virgin soil where such crop production hazards are much less of a problem.

THE INHERITANCE OF EGG SHELL COLOR IN SYNTHETIC MEAT TYPE POPULATIONS OF CHICKENS

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POULTRY PRODUCERS have long known that the color of the shells of eggs is more or less a breed and/or family characteristic and that normal environment has little, if any, effect on it. Poultry breeders must, therefore, resort to selection in order to alter the shell color of their strains.

All of the currently popular meat type and broiler varieties lay brown eggs. Standard breeds of chickens which lay white eggs usually lack meat type. Many hybrids have been produced by crossing white egg and brown egg strains. Progeny of such crosses lay eggs of various shades of color, but generally intermediate between the parental lines.

Egg buyers may not object to intermediate shell color alone, but it is believed that most people prefer at least a uniform shade of color in the same pack. This report contains results that indicate the probable number of generations required to get a white egg-meat type strain and the variation in shades of color to expect among breeds and crosses.

Previous Research

Practically all of the reports of the inheritance of shell color are available in two books[1, 2] on poultry breeding. A continued search has not yielded any more recent experimental evidence.

It is difficult to make comparisons with early investigations because of the varying circumstances and criteria used. In some reports the classification of colors of shell phenotypes is loose and vague. Frequently, shell color phenotypes are designated as "brown" or

[1]Jull, M. A. (1952). *Poultry Breeding.* John Wiley & Sons, N.Y., 398 pp.
[2]Hutt, F. B. (1949). *Genetics of the Fowl.* McGraw-Hill, N.Y., 590 pp.

ARTICLE 40-113

"white" without discrimination between shades of color within populations. In some cases parental stocks were designated as brown or white, by breeds, on the probable assumption that all members of a breed lay eggs of the same color and that they transmit this character uniformly.

In general, recent reports agree that: (1) Shell color is variable within and between breeds, strains, and families; (2) it is quantitative genetically. In other words, it is not a unit character such as comb type and certain plumage colors are known to be; and (3) the shell color of white-brown crossbred progeny is usually intermediate in color between parental types, but highly variable.

Neither brown nor white shells were invariably dominant, but our data will show the relative dominance of white over brown. Blue eggs have been reported dominant over white (one report[3]). Others indicate linkage of the blue egg and Pea comb genes. Unpublished data at this station from a single cross of brown egg x blue egg stocks resulted in olive-drab shelled[4] progeny. No evidence of the blue egg gene has appeared among the populations described in the present report, although the Cornish is a well known Pea combed breed.

None of the aforementioned reports involved modern spectographic measures of shell color. Many of the studies did not differentiate between shades of color within strains in any way, but at least one of the reports included visual estimations of shades of brown ranging from score (1) white to (13) dark brown.[5]

Purposes of This Report

The purposes of this report are: (1) To record the egg shell color of several M. S. U. meat type synthetic varieties; (2) to show the degree of variability in shades of color in parental stocks and progeny resulting from several kinds of matings, especially the F_1, F_2 and backcross generations; and (3) to suggest the probable number of generations which may be required to recover a white egg strain from an original cross or hybrid.

[3]Punnett, R. C. (1933). Genetic studies in Poultry IX. The Blue Egg. Jour. Gen. 24: 265-70. (Cited by Jull, 1952.)

[4]Unpublished observation, Mich. Agr. Expt. Sta. Project 266.

[5]Kopec, Stefan (1926). Some data referring to size, shape, and weight of eggs in the domestic fowl. (Cited by Jull, 1952.)

METHODS

Parental Varieties

The parental varieties were principally Red Cornish, Red Laced Silver Cornish, and Silver Laced Cornish as brown egg strains; a few White Rocks were included. The Red, Buff, and Black varieties of leghorns were used as white egg strains.

Individual Pedigree Program

All stocks were individually pedigreed. All females have been trapnested each year since their inception at this station. Only those known by pedigrees to belong to the ancestral populations were included. Classification in any particular shell color category is not based on breed or strain relationship therefore, but upon the recorded color of the shell of female relatives (sisters, in the case of males).

For instance, the ancestors of the M. S. U. Red Cornish consisted of New Hampshires, Rhode Island Reds, and Cornish. All those breeds are brown egg layers, in general, but only those known and tested at this station for more than five generations are represented in this report.

The same restrictions applied to our strain of Red Leghorns which now have a trace of Cornish blood. (Cornish were crossed with Red Leghorns in 1953 to provide a Pea combed character.) They were white egg layers therefore, only to the extent indicated by the recorded shell colors (Table 1).

A precise individual classification among many Standard-bred populations would probably reveal a similar departure from ideal shell color. It is well known that many Standard-bred white egg strains lay tinted, cream and/or light brown eggs. Inbreeding of White Leghorn strains has been known to increase the incidence of off-white eggs.

Methods of Recording Shell Color

The shell color scoring system adopted in this investigation was dictated by two circumstances beyond our control: (1) Precise spectographic equipment was not available, and (2) egg color was necessarily subordinate to the main objectives of the original cross-breeding project.

The shell color scoring system, adopted for the purpose of establishing individual shell color indices, consisted of a visual estimation

of shade of color by the trap nest operator, of 10 consecutive eggs from each individual hen. In most cases, the shell color "score" ranging from (1) white to (10) brown was verified before setting time in the spring.

Normally, the average color score of the first 10 eggs laid was used as the color index for each hen. Errors of judgment and differences of opinion were possible, of course, but they were reconciled when the eggs were sorted at setting time.

RESULTS

Description of Shell Color Populations

The various shell color populations are shown in Table 1. The distribution of shades of brown may or may not be typical of brown-egged populations in general, but it is the actual distribution of the ancestral populations tested and used in matings at this station. Selection of individuals within populations was entirely random.

TABLE 1—Egg color scores

	parental brown		parental white		F_1		F_2		Bx		Bx	
Score	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent
1	..	..	78	53	28	31	12	32	16	42	1	2
2	10	5	49	33	27	30	11	30	11	29	13	24
3	32	15	17	11	16	18	11	30	7	18	11	20
4	43	20	5	3	12	14	2	5	4	11	5	9
5	41	20	..	..	1	1	1	3	..	..	9	17
6	26	13	..	..	5	6	..	..	..	..	4	7
7	32	16	..	..	..	..	..	..	..	..	5	9
8	11	5	..	..	..	..	..	..	..	..	3	6
9	4	2	..	..	..	..	..	..	..	..	1	2
10	8	4	..	..	..	..	..	..	..	..	2	4
Totals	207	100	149	100	89	100	37	100	38	100	54	100

The parental white-egged population as shown in Table 1 is perhaps more representative or realistic than it is ideal. Even if the population had been restricted exclusively to white-egged phenotypes, there could be no assurance that all the individuals were free from genes for tinted or cream colored eggs.

The percentage of individuals in the several shell color grades is shown with the numbers, because the total numbers varied from one population to another.

Averages of Shell Color Score

For those interested in more precise mathematical descriptions, the averages of the several populations are as follows: The average egg shell color score of the brown egg population is 5.2. Other averages are: Parental white egg—1.6; F_1 (both white sire x brown dam and vice versa)—2.4. Reciprocal cross progeny were combined because the average shell color score was identical (2.4) regardless of which way the cross was made.

DISCUSSION

The distribution of the F_2 population is shown in Table 1. The relative dominance or epistasis of white eggs over brown eggs is shown by the high percentage of the population (62 percent) in the white or near white class and only 8 percent in the medium brown classes. The average color score of the F_2 population is 2.1. The indication of dominance confirms in part the report of Kopec (1926).

Additional evidence of the relative dominance of white eggs over brown may be obtained from the distributions of the two backcross generations in Table 1. The back cross of the F_1 population with the white egg strain yielded female progeny with an average egg color index of 1.9. Seventy-one percent of the population was white or barely tinted (Chi Square—16.0). By interpolation, 80 percent was nearer white than the average of the F_1 (2.4).

The F_1—brown, back cross progeny exhibited an average egg color index of 4.4. The mid-point between the brown (5.2) and F_1 population (2.4) is 3.8 (or (4)—to the nearest whole number). Again a major fraction of the back cross generation is lighter colored than the average and 72 percent of it is lighter colored than the average of the brown population (5.2).

If there were no dominance or epistasis of either white or brown colored eggs there should be about as many individuals above as below the averages in the F_1, F_2, and back cross populations.

A Chi Square test of the Brown—F_1 back cross population, which exhibits the nearest approach to a no dominance theory, showed that it was not significant when compared with the midpoint. It was significantly lighter colored than the average of the brown egg population (5.2) (Chi Square—5.2).

Number of Generations To Recover the White Egg Character

From our experience with progeny of white egg-brown crosses, it seems that a substantial number (25 to 30 percent) of white-egged individuals may be expected in the first generation because of partial dominance of white over brown. That all these white-egged females will not breed true is shown by the distribution of the F_2 generation. The back cross of the white egg population, which might reasonably be expected to yield more white-egged females than the F_2, yielded 42 percent.

Progeny tests of individuals by pedigree mating with known brown-egged phenotypes would seem to be the most logical procedure. Selection should then be made from individuals which yield the greatest number of white-egg progeny. In general, our Red Leghorns were produced in that way but with mild selection pressure, because of other project objectives. From the distribution of white-egg progeny, shown in Table 1, it appears that at least four generations would be required to recover the white egg character in substantial numbers.

SUMMARY

The relative shell color of brown- and white-egged M. S. U. synthetic meat type populations is shown by percentage of the distributions in color classes. The distributions of shell colors of the F_1, F_2, and back cross descendants of brown and white egg crosses are described and discussed. The results indicate the relative dominance or epistasis of white over brown with no sex linkage, maternal or paternal effects. The data suggest that a minimum of four back cross generations would be required to recover a white-egged strain.

JOURNAL ARTICLE ABSTRACTS

Testing for Differences Between Methods of Preparing Fish By Use of a Discriminant Function

BATEN, W. D.; P. I. TACK AND HELEN A. BAEDER

Industrial Quality Control 14:7-10. 1958. (Journal Article 1455 from the Michigan Agricultural Experiment Station)

Fish were prepared by three methods and served to a trained panel of judges who graded each sample on aroma, flavor, texture, and moisture. The averages of the scores of the judges were considered the final score for the particular fish; 12 fish were sampled for each preparation.

A discriminant function enables one to determine the best method for preparing fish by considering the scores on these four characteristics together. A linear compound pertaining to each method is made up of the scores on aroma, flavor, texture, and moisture. Discriminant functions make it possible to determine significant differences between these compounds. This statistical technique also indicates which characteristic is most important, which is next in importance, etc., for distinguishing differences in fish.

The second part of the paper shows the relationship between discriminant functions and linear multiple regression.

The study revealed vast differences between the preparation methods.

The Impact of Technological Changes on Milk Production

WHEELER, R. G.

Journ. of Farm Econ. 37:996-1,004. 1955. (Journal Article 1801 from the Michigan Agricultural Experiment Station)

It seems fair to conclude that recent technological developments are leading to a higher degree of specialization on dairy farms and to increasing output per farm. However, there does not seem to be any significant increase in farm size as measured by the number of workers in the regular labor force.

In city milk markets, the intensity of competition between nearby and distant producers is likely to increase, with peripheral areas accounting for more than a proportionate share of any change in total production.

Even at constant prices, the amount of capital needed per man has been increasing substantially, and the proportional importance of capital and management inputs have been gaining relative to labor inputs.

Cytochrome Oxidase in Cells of the Genus *Brucella*

RICHARDSON, MARVIS

Journ. of Bact. 74:699-706. 1957. (Journal Article 1890 from the Michigan Agricultural Experiment Station)

Conditions were selected to permit the quantitative determination of cytochrome oxidase activity of brucellae. Oxygen uptake of a given number of cells

at pH 6.2 and in the presence of 0.07 *M* p-phenylenediamine is about four times greater than that obtained at pH 7.3 in 0.02 *M* reductant, the conditions generally used for measuring cytochrome oxidase activity. Activity was expressed as microliters of oxygen taken up by 10^9 viable cells per hour.

The cytochrome oxidase activity of 24 thionin-sensitive strains of *Brucella abortus* was 22.5 to 33.0; the activity of four thionin-resistant strains of *Br. abortus* was 9.0 to 12.0; the activity of 15 strains of *Brucella melitensis* was 7.5 to 24.5; the activity of 22 strains of *Brucella suis* was 5.0 to 14.5. Although the degree of cytochrome oxidase activity differentiated recently, isolated typical *Br. abortus* from *Br. suis,* it did not permit their differentiation from *Br. melitensis.*

Problems Involved in the Integration of Agronomics and Economic Methodologies in Economic Optima Experiments

ROBERTSON, L. S.; G. L. JOHNSON AND J. F. DAVIS

Economic and Technical Analysis of Fertilizer Innovations and Research Use. 226-243. 1956. (Journal Article 1923 from the Michigan Agricultural Experiment Station)

The following factors are important in the design of economic optima fertilizer experiments. Flexibility in selection of production functions; soil inventory before initiation; inclusion of a 3 by 3 by 3 factorial with two replications in the design with treatments assigned to separate blocks; secondary and minor elements; fertilizer placement; variety fertilizer interactions; plant population; fertilizer carriers; quality and date of maturity of several crops; correlation of soil and tissue tests with crop responses and minimum tillage. The plot size, number of replications, and design should be adjusted to the land available, the equipment used, and the crop grown. Experiments should be designed to answer questions that will be presented in the future.

These types of experiments offer an excellent opportunity for the agronomist and economist to complement their work.

Factors Affecting the Evaluation of Liquid Fertilizer

ROBERTSON, L. S.; J. F. DAVIS AND C. M. HANSEN

Economic and Technical Analysis of Fertilizer Innovations and Research Use. 57-61. 1956. (Journal Article 1925 from the Michigan Agricultural Experiment Station)

Because liquid fertilizers are relatively new, only limited information is available on the results from their use. In 1955, where liquid and solid fertilizers were compared, both forms had equal effects on the yield of wheat and oats. At two out of four locations, corn yielded less where liquid fertilizer was used. In trials on organic soils, liquid fertilizer resulted in lower yields of onions, carrots, and table beets than were obtained from plots where the fertilizers were dry materials.

Liquid fertilizers are of value as starter solutions. Foliar applications have increased crop yields. An evaluation of liquid fertilizers should consider the advantages and disadvantages of its use as compared to the conventional dry fertilizers, as well as its effect on crop yields.

A Strain Gage Cell for Measuring Pressures in Soil

COOPER, A. W.; G. E. VANDENBERG, H. F. MCCOLLY AND A. E. ERICKSON

Ag. Engr. 38:232-235, 246. 1957. (Journal Article 1957 from the Michigan Agricultural Experiment Station)

A type A strain gage pressure cell reported in this article will measure soil pressure with a reasonable degree of accuracy when suspended in a homogeneous soil mass. A thick pressure cell gives an erroneous reading because the soil around the cell compacts and the cell compresses very slightly.

According to calculations, using Froehlich's formula, deep soil compaction is a function of the total load applied to the surface and the area over which it is applied and is not a function of unit pressure alone.

In a very dense soil when the entire load on the rear axle of the tractor was carried on the lugs, tires with 16 p.s.i. air pressure applied an average pressure of 54 p.s.i. to the soil. Pressures as high as 43 p.s.i. were measured in the soil at a 2-inch depth.

Changes in the Biacetyl Content of Creamed Cottage Cheese Caused by Organisms Associated with Spoilage

WALES, C. S. AND L. G. HARMON

Food Res. 22:170-175. 1957. (Journal Article 1961 from the Michigan Agricultural Experiment Station)

Several organisms commonly identified with spoilage in cottage cheese were individually inoculated into creamed cottage cheese which was stored at 50° and 40° F. for 6 and 12 days, respectively. The biacetyl content of most of the inoculated cheese was below that of the corresponding controls, which usually contained from 1.5 to 2.5 p.p.m. The *pseudomonas* organisms caused greater decreases in biacetyl than any other organisms studied.

No appreciable changes occurred in the acetylmethylcarbinol content of inoculated cheese stored at 40° F. Cheese inoculated with *Rhodotorula flava, Achromobacter eurydice, Pseudomonas fragi,* and *Pseudomonas fluorescens,* and stored at 50° F. showed continuous decreases in acetylmethylcarbinol.

Variations in biacetyl and acetylmethylcarbinol were not consistently related to the pH of the inoculated samples studied. Neither could organoleptic quality be correlated to the biacetyl content of the inoculated samples of cheese.

Some Basic Properties of Infectious Bronchitis Virus

CUNNINGHAM, C. H.

Amer. Jour. of Veterinary Res. 18:648-654. 1957. (Journal Article 1966 from the Michigan Agricultural Experiment Station)

Infectious bronchitis virus (IBV) is spherical, averaging from 60 to 100 mu. Inclusion bodies are not observed. The chicken is the natural host. IBV can be propagated in embryonating chicken eggs and tissue culture. The rabbit and Swiss mouse are not suitable hosts.

Neutralizing antibodies are produced in chickens. A brief, but transient relationship exists between blobulins and neutralizing antibody. From 84 to 91 percent of infectivity neutralizing potentials of anti-IB serum is utilized immediately on contact with IBV. Interference occurs between active and heat-inactivated

IBV, influenza, and Newcastle disease viruses. Thermal inactivation of IBV is exponential.

The chemical agents commonly used for disinfection inactivate IBV. Penicillin and streptomycin are without effect. Viscosin and polylysine are effective under certain conditions.

The Effects of Endocrine Imbalances on Vitamin Requirements

MEITES, J.; Y. S. L. FENG AND A. M. WILWERTH

Amer. Jour. of Clinical Nutr. 5:381-392. 1957. (Journal Article 1968 from the Michigan Agricultural Experiment Station)

We have suggested the following hypothesis to explain the interactions between large doses of cortisone and vitamin B_{12}: (a) When large doses of cortisone are injected into young rats deficient in this vitamin, there is a pronounced increase in gluconeogenesis from protein, hyperglycemia, and an increase in insulin secretion. Cortisone and the vitamin B_{12} deficiency interfere with normal insulin action, increasing the hyperglycemia and glucosuria, and leaving little carbohydrate available for anabolic purposes. These lead to inhibition of body and hair growth and losses in weight of lymphoid tissues.

(b) When large doses of cortisone are given to young rats fed an abundant intake of vitamin B_{12}, there is an increase in food consumption and availability of carbohydrate. These stimulate insulin secretion and thereby promote carbohydrate utilization for energy and storage purposes, with a resultant reduction in protein catabolism by cortisone, leaving more protein, as well as carbohydrate, available for body-building purposes. Presumably some, but not all, of the interactions between large doses of cortisone and thiamine or pyridoxine would be similar in nature.

Amputation of Foreleg in Small Animals

W. O. BRINKER AND T. W. JENKINS

Jour. of the Amer. Veterinary Medical Assoc. 130:126-129. 1957. (Journal Article 1972 from the Michigan Agricultural Experiment Station)

The three main indications for removal of the foreleg are (1) foreleg paralysis, (2) neoplastic involvement, and (3) extensive injury or infection or both. Surgical removal can be a gratifying operation when a definite sequence is followed. Small animals adapt themselves quickly and well to three legs. The step by step procedure is described and illustrated.

Saintpaulias—The Effect of Temperature of the Rooting Medium Upon Root and Shoot Formation

STINSON, R. F. AND R. S. LINDSTROM

Mich. Florist, Jan.:7. 1957. (Journal Article 1977 from the Michigan Agricultural Experiment Station)

To determine the effect of propagation medium temperature upon root and shoot fermentation, leaf-petiole cuttings of four *Saintpaulia ionantha* varieties were stuck in silica sand in water-tight crocks in controlled-temperature water bath tanks. Medium temperatures were 65°, 70°, 75°, and 80°F.

The time for root formation varied from 16 to 24 days; while the time to shoot formation varied from 41 to 58 days.

Results of the study indicate that a propagation medium temperature 75°F., with an air temperature of 65°F. is optimum for root and shoot formation with the varieties used.

Soil Pressure Distribution Under Tractor and Implement Traffic in an Artificial Field

VANDENBERG, G. E.; A. W. COOPER, A. E. ERICKSON AND W. M. CARLETON

Ag. Engr. 38:854-855, 859. 1957. (Journal Article 1979 from the Michigan Agricultural Experiment Station)

With the development of a strain gage pressure cell (transducer) capable of measuring soil pressures caused by implement traffic, a means is provided whereby magnitude and distribution of soil pressures can be determined. This paper deals with such an attempt in an artificial field under partially controlled conditions.

The pressure cells were placed in the soil such that pressures in a horizontal line perpendicular to the direction of travel could be measured as the traffic passed over the cells. Through special techniques, soil pressures from 1 inch to 14 inches in depth were measured under the front and rear wheel of a tractor pulling a plow. These soil pressures were analyzed by a graphical method which permitted obtaining isopiestic lines for both tires. A summary of other soil pressure measurements is presented in tabular form.

The Effect of Fertilizer Applications on Quackgrass Control With Dalapon Treatments Before Planting Vegetables

RIES, S. K.

Proc. 13th Ann. Meeting, NC Weed Control Conf. 60-61. 1956. (Journal Article 1988 from the Michigan Agricultural Experiment Station)

Previous research has indicated that dalapon (2,2 dichloroproprionic acid) sometimes injures beans or corn planted as close to application as in this test, (6 days for beans and cucumbers; 17 days for corn). The early part of this season, however, was characterized by heavy rainfall and warm temperatures, which favored dalapon breakdown, and no injury resulted. Under these conditions, the following may be concluded:

1) Commercially acceptable control of quackgrass was obtained only with (a) 17 pounds per acre of dalapon applied early (May 10), (b) 8.5 pounds applied late (June 19), and (c) a combination of 8.5 pounds early and 8.5 pounds late.

2) Better grass control was obtained in treated areas fertilized a month prior to the first application of chemicals. Both 121 pounds per acre of ammonium nitrate and 333 pounds per acre of 12-12-12 resulted in better control. The application of 12-12-12 was no better than the ammonium nitrate.

3) There was no injury from any treatment to snap beans, cucumbers, or sweet corn.

4) The combination treatments, 4.2 pounds early plus 4.2 pounds late, and 8.5 pounds early plus 8.5 pounds late were no better than a single application of 8.5 pounds late.

The Effect of Gibberellic Acid on Enzyme Activity and Oxygen Uptake in Bean Plants *(Phaseolus Vulgaris)*

WELLER, L. E.; S. H. WITTWER, M. J. BUKOVAC AND H. M. SELL

Plant Physiol. 32:371-372. 1957. (Journal Article 1997 from the Michigan Agricultural Experiment Station)

Bean plants treated with gibberellic acid showed an increase in the activity of β-amylase and phosphatase in the stem tissue. Phosphatase and pectin methylesterase activities were increased in the leaves of treated roots. No differences could be detected for α-amylase and phosphorylase activities in any tissues examined. Oxygen uptake was increased in the stems of gibberellic acid-treated plants.

A Quadratic Programming Procedure

HILDRETH, C.

Naval Res. Logistics Hty. 4:79-85. 1957. (Journal Article 2001 from the Michigan Agricultural Experiment Station)

Problems of maximizing a quadratic function subject to linear inequalities (or mixed equalities and inequalities) arise in certain economic applications of programming involving imperfect competition or uncertain prices and in some statistical applications involving a prior information of a qualitative nature.

An iterative procedure for solving such problems is developed. Compared with alternative methods that have been suggested elsewhere, this procedure has the disadvantage that it approaches a solution only asymptotically and the compensating advantage that successive steps in the iteration are easily performed.

Price Support Programs and Inter-regional Competition

SORENSON, V. L.

Jour. of Farm Econ. 38:1,650-1,659. 1956. (Journal Article 2007 from the Michigan Agricultural Experiment Station)

This paper attempts to set forth certain hypotheses concerning the impact that price programs have on inter-regional competition. It is not exhaustive, but does suggest certain conclusions that warrant emphasis.

Price programs influence asset accumulation rates by creating income transfers both within agriculture and between agriculture and other groups in society. The patterns that these income transfers take will depend both on the level at which prices are set and differences in the ability of farmers to make output adjustments designed to take advantage of price relationships and offset the effect of acreage restrictions. The permanency of these adjustments will depend on the extent to which they are associated with the adoption of cost-reducing techniques and involve committee long-term specialized inputs that tend to fix the enterprise organization that has been adopted.

The welfare implications of these adjustments must be viewed in the light of potential benefits to other segments of the economy through the causal effect that price programs have in permanently lowering production costs and in turn the general level of food prices. These gains must be related to the income transfers brought about during the time programs are in effect.

A second welfare consideration arises from the fact that some farmers may obtain a permanent advantage while others are at a permanent disadvantage with the result that a realignment of income levels is created within agriculture.

Nutritional Status of Selected Plantings of *Taxus Media Hicksi*

BOONSTRA, R.; A. L. KENWORTHY AND D. P. WATSON

Amer. Soc. for Hort. Sci. 70:432-436. 1957. (Journal Article 2008 from the Michigan Agricultural Experiment Station)

Samples of shoot tips were collected from *Taxus media hicksi* and analyzed for 10 essential nutrient-elements. The analyses indicate that such samples may be used to diagnose nutritional needs of *Taxus*. Early spring, prior to growth, and mid-summer, seem to be desirable periods for collecting samples. Variations in composition as influenced by location, age of plants, and time of sampling were studied.

Bacteriological Condition of Water Supplies in Dairy Plants

HARMON, L. G.

Jour. of Milk and Food Tech. 20:196-199. 1957. (Journal Article 2012 from the Michigan Agricultural Experiment Station)

Samples of water supplies used in 14 butter and 12 cottage cheese plants were examined for total, coliform, lipolytic, proteolytic and psychrophilic bacteria populations.

Most of the water samples were free from coliform bacteria, but contained psychrophylic, proteolytic, and lipolytic organisms. This indicates that the coliform test alone does not afford enough information about the microbiological condition of water supplies intended for dairy plant use.

Water samples taken at or near the source where the water entered the plant, usually contained fewer bacteria than samples taken at the churn door or cheese vat, suggesting contamination of the water lines within the individual plants.

Anatomical Changes in the Fruit of the Rubel Blueberry During Storage in Controlled Atmospheres

BUNEMANN, GERHARD; D. H. DEWEY AND D. P. WATSON

Proc. of Amer. Soc. for Hort. Sci. 70:156-160. 1957. (Journal Article 2019 from the Michigan Agricultural Experiment Station)

Rubel blueberry fruit were stored at 32, 40, 50 and 72°F. Acceptable market quality was retained 4 to 6 weeks only at 32°. Controlled atmospheres retarded breakdown and decay, but caused off-flavors associated with fermentation. Fruit harvested upon reaching a blue skin color ("Hard Ripe") stored better than riper fruit ("Firm Ripe" and "Ripe").

The development of a tough texture was associated with corrugation of the epidermal and hypodermal cell walls. It was favored by storage at 50° and prevented at 32°F. The combination of 5 percent CO_2: 2 percent O_2 caused pronounced corrugation; whereas, 16 percent CO_2: 5 percent O_2 and normal air resulted in slight corrugation. Corrugated cell walls were more prevalent in "Ripe" than in "Hard Ripe" berries.

Woody flesh characteristics, which also developed during storage and could be noted organoleptically, were not anatomically verified. The anatomy of the peripheral tissues of blueberry fruit is illustrated and described.

Sugar Beet Yield as Affected by Crop Rotation and Weather

GUTTAY, J. R.

Proc. of the Amer. Soc. of Sugar Beet Tech., Eastern U. S. and Canada. 9:122-125. 1957. (Journal Article 2031 from the Michigan Agricultural Experiment Station)

The lowest average sugar beet yields have resulted in rotations where beets have followed directly after alfalfa. The highest yields occurred in rotations where an intervening crop of beans or corn has been grown between the alfalfa and sugar beets. Beets in rotations utilizing clover green manure crops have produced nearly as well as those in rotations with alfalfa. Where green manure crops have not been used, nitrogen sidedressing has increased beet yields nearly equivalent to those produced with green manure crops.

Sucrose percentage has been lowest in beets grown after alfalfa and highest in a non-legume rotation. Fertilizer rate has had little effect on sucrose percentage although nitrogen sidedressing has lowered it particularly where beets have followed alfalfa.

The yields of beets over an 11-year period have been negatively correlated with spring rains; yields decrease with increasing April to June precipitation.

Seedlots from Individual Plants of a Sugar Beet Variety Differ in Speed of Germination

SNYDER, F. S.

Proc. Amer. Soc. of Sugar Beet Tech., Eastern U. S. and Canada. 9:102-104. 1957. (Journal Article 2035 from the Michigan Agricultural Experiment Station)

Seedlots of sugar beet have been classified for speed of germination by a technique standardized in the laboratory. The seeds are germinated in closed plastic boxes in contact with a balanced nutrient solution of 10.1 atmospheres osmotic pressure. A surprising range in speed of germination of seed harvested from individual plants of a variety grown in the same plot has been observed by this technique.

Experiments were conducted to ascertain whether rapid germinators, as determined by this nutrient solution technique, will emerge more rapidly than slow germinators when both are placed in soil. Seedlots which germinated slowly in contact with nutrient solution in plastic boxes also emerged slower from soil than seedlots germinating rapidly by the laboratory technique. The nutrient solution technique offers a relatively simple procedure for locating rapid-germinating sugar beet seed.

Soil Compaction for Optimum Sugar Beet Seedling Emergence, as Influenced by Soil Moisture, Depth of Planting, and Aggregate Size

STOUT, B. A. AND F. W. SNYDER

Proc. Amer. Soc. of Sugar Beet Tech., Eastern U. S. and Canada. 9:106-114. 1957. (Journal Article 2042 from the Michigan Agricultural Experiment Station)

Reduced emergence of sugar beet seedlings resulted when compaction pressure above 5 p.s.i. was applied momentarily to the soil surface. Low compaction pressure

(½ to 5 p.s.i.) resulted in better emergence than no pressure. The soil moisture content was maintained at three levels—near wilting point, intermediate, and near field capacity. Planting depths of ½, 1, and 1½ inches were used.

In another laboratory experiment, soil was screened into five aggregate size classes and plantings were made. The above trends were exhibited in all aggregate size classes.

In a field experiment, compaction pressures of ½, 5, and 10 p.s.i. were applied to the soil surface. The fastest and highest percentage of emergence resulted from the ½-p.s.i. treatment.

Laboratory and Greenhouse Studies on Effect of Lime and Other Amendments on Water-Soluble Boron in Soil

BISHOP, R. F. AND R. L. COOK

Canadian Jour. of Sci. 38:27-35. 1958. (Journal Article 2044 from the Michigan Agricultural Experiment Station)

Greenhouse and laboratory experiments were used to study the effect of various soil amendments on the water-soluble boron content of a strongly acid soil.

In the greenhouse, using ladino clover as the test crop, liming reduced boron availability as measured by soil and plant analysis. Calcium-boron ratios in the clover ranged from about 550:1 to 2,000:1 and there was a significant correlation between the water-soluble boron in the soil and the boron content of the clover.

In the laboratory studies, calcium and magnesium carbonates were equally effective in decreasing water-soluble boron in soil. Gypsum was ineffective. Manure or alfalfa hay increased the water-soluble boron content of soil in proportion to the amounts applied.

Applications of sodium hydroxide, resulting in a range of soil pH values from about 4.8 to 9.7, were accompanied by decreases and then increases in water-soluble boron. At comparable pH values of approximately 7.0 or less, sodium hydroxide caused a smaller reduction in water-soluble boron than did either calcium or magnesium carbonate.

Progress Report on Weed Control in Sugar Beets

HAMILTON, R. H. AND B. H. GRIGSBY

Proc. Amer. Soc. of Sugar Beet Tech., Eastern U. S. and Canada. 9:74-78. 1957. (Journal Article 2050 from the Michigan Agricultural Experiment Station)

A number of chemicals were evaluated in the greenhouse and field for weed control in sugar beets during 1955 and 1956.

A considerable amount of work was done in 1955 on eight carbamate derivatives in addition to IPC and CIPC. It appeared that N-(3-methylphenyl) carbamate gave relatively little injury to sugar beets when applied at rates up to 16 pounds per acre pre-emergence.

Several urea derivatives were tested both in the greenhouse and field during the past 2 years. As little as ¾ pound per acre was found to result in severe injury in post-emergence applications in 1956. It appears that these derivatives can not safely be used on sugar beets on mineral soils.

Weed control in 1955 was very good with pre-emergence applications of TCA, dalapon, and endothal. DCU gave good grass control. In 1956, under

relatively dry conditions after pre-emergence treatment, no chemical except CDAA gave satisfactory control. This chemical had given poor control pre-emergence in 1955 under relatively wet conditions.

Absorption and Mobility of Foliar Applied Nutrients

BUKOVAC, M. J. AND S. H. WITTWER

Plant Physiol. 32:428-435. 1957. (Journal Article 2059 from the Michigan Agricultural Experiment Station)

The absorption, transport, and mobility of foliar applied radioactive isotopes of rubidium, sodium, potassium, phosphorus, chlorine, sulfur, zinc, copper, manganese, iron, molybdenum, calcium, strontium, and barium were determined with the bean as the experimental plant.

The percent of the foliar applied radioactive isotope recovered in non-treated plant parts was used as a criterion. Autoradiography was used to portray gross distribution in the plant.

It was found that rubidium, sodium and potassium were the most readily absorbed and most highly mobile. Calcium, strontium, and barium, while absorbed by the leaf, were not exported from the leaf and were considered immobile. Phosphorus, chlorine, sulfur, zinc, copper, manganese, iron, and molybdenum were intermediate with decreasing mobility in the order given.

The Effect of Drugs on the Isolation of *Salmonella Gallinarum* from Inoculated Chicks

TITKEMEYER, C. W. AND S. C. SCHMITTLE

Poult. Sci. 36:1,198-1,206. 1957. (Journal Article 2061 from the Michigan Agricultural Experiment Station)

Various levels of six different drugs were used to determine their effect on the recovery of S. *gallinarum* from White Leghorn chicks inoculated with the organism. Representing the sulfa drugs, sulfaquinoxaline and sulfamethazine at prophylactic and therapeutic levels resulted in an organism recovery incidence of 82.5 percent as compared to 100 percent in the intraperitoneally inoculated controls.

At "growth-promoting" levels, chlortetracycline and penicillin did not significantly reduce the percentage of isolation of the organism.

At therapeutic levels chlortetracycline and neomycin reduced the incidence of recovery of the organism from 100 percent in the controls to 90 percent. Furazolidone at therapeutic level reduced the incidence of recovery to only 10 percent. With oral inoculation of the organism, the results were less conclusive, although furazolidone seemingly prevented isolation of the organism from all chicks.

The Structure of Agriculture

CROMARTY, W. A. AND J. T. BONNEN

Agricultural Adjustment Problems in a Growing Economy, Iowa State College Press. 109-127. 1958. (Journal Article 2062 from the Michigan Agricultural Experiment Station)

The first part of the paper, by W. A. Cromarty, discusses an economic structure of agriculture which may be used to generate supply and demand functions

for 13 agricultural commodities. One supply relation applies for each commodity and where appropriate demand relationships covering commercial, government, and inventory utilization are discussed. Interactions between commodities, demands, and supplies are illustrated in two examples.

The second part of the paper, by J. T. Bonnen, presents a long-run model for agriculture set at a time horizon of 1965. The emphasis is on the method of construction, although some empirical results of the model are presented. The model is designed to provide quantitative estimates of the effect which changing population, per capita consumption shifts, improving technology, and other structural changes would have on the balance of production and consumption. Thus, the model provides estimates of the size of the annual surplus of production which would tend to occur as a result of structural changes over the next decade.

Utilization of Inorganic Sulfate by Rumen Micro-organisms 1. Incorporation of Inorganic Sulfate into Amino Acids

EMERY, R. S.; C. K. SMITH AND C. F. HUFFMAN

Applied Microbiology 5:360-362. 1957. (Journal Article 2064 from the Michigan Agricultural Experiment Station)

Liquid from the rumen of five cattle has been incubated *in vitro* with labeled inorganic sulfate and substrates representative of concentrate and roughage rations. Incorporation of the inorganic sulfate into organic compounds was faster with the rumen liquid from bovine fed high concentrate rations. The formation of cystine was about twice as great as the formation of methionine during the 3-hour incubation period. Evidence was obtained showing that a large proportion of the cystine activity was in the form of glutathione. Microradioautographs indicated that a relatively small number of the many types of bacteria in rumen liquid are responsible for this incorporation.

Utilization of Inorganic Sulfate by Rumen Micro-organisms 2. The Ability of Single Strains of Rumen Bacteria to Utilize Inorganic Sulfate

EMERY, R. S.; C. K. SMITH AND L. FAI TO

Applied Microbiology 5:363-366. 1957. (Journal Article 2065 from the Michigan Agricultural Experiment Station)

A survey of 10 cultures of rumen bacteria revealed that only five utilized a significant amount of inorganic sulfate in the synthesis of organic sulfur compounds and only three incorporated inorganic sulfate into their microbial proteins when cystine was present in the medium.

One of these cultures, *Lachnospira multiparus,* incorporated about equal amounts of inorganic sulfate into glutathione and microbial protein when cystine was present in the medium, but failed to form radioactive glutathione when S35-labeled inorganic sulfate was the only source of sulfur. *L. multiparus* utilized less than 0.2 percent of the inorganic sulfate when cystine was present as an alternate sulfur source as compared to 22 percent when inorganic sulfur was the only sulfur source. This occurred even though much more growth took place in the presence of cystine.

Ultrasonic Irradiation of Milk. I. The Effect of an Electric Current on the Efficiency of Ultrasonic Homogenization

NEWCOMER, J. L.; C. W. HALL, J. R. BRUNNER AND C. K. SMITH

Jour. of Dairy Sci. 40:1,416-1,423. 1957. (Journal Article 2069 from the Michigan Agricultural Experiment Station)

An electric current was passed through milk during irradiation with ultrasonic energy produced from a focusing transducer. By increasing the current strength the homogenization efficiency was improved up to a certain level. The homogenization efficiency was improved by using the electrode at the focal point of the irradiation zone as negative and the outer container, which was the transducer bowl, as positive.

Radiation–Induced Changes in Bread Flavor

NICHOLAS, R. C.; D. P. MEISKE, M. F. JONES, D. E. WIANT, I. J. PFLUG AND E. M. JONES

Food Tech. 12:52-54. 1957. (Journal Article 2078 from the Michigan Agricultural Experiment Station)

Bread made from iradiated flour and from flour milled from irradiated wheat was tasted to determine the level at which flavor change could be detected. A statistical analysis of the data placed the level at which 50 percent of the judgements (above chance) were correct at about 50,000 rep in both cases.

Up to 500,000 rep there was no significant change in the loaf volumes of bread made from irradiated flour; the loaf volumes of bread made from flour milled from wheat irradiated at 40,000 and 50,000 rep were significantly higher than at 250,000 rep.

Influence of Trace Elements on the pH of Ensiled Alfalfa

DEXTER, S. T.

Agronomy Jour. 50:53-54. 1958. (Journal Article 2082 from the Michigan Agricultural Experiment Station)

Addition of small amounts (1 to 300 p.p.m.) of various metallic sulfates—manganese, cobalt, iron, zinc, copper, and magnesium—at the time of ensiling appeared to have little effect upon the fermentation of alfalfa into silage. Slight increases in acidity were ordinarily about equal to those due to the addition of the chemical, as such, rather than to increases in favorable fermentation. Little or no detrimental effects were observed from addition of metallic elements that have been described as antagonistic to lactic acid fermentation.

Occurrence of Multiple Hemoglobins in Certain Breeds of Dairy Cattle

GRIMES, R. M.; C. W. DUNCAN AND C. A. LASSITER

Jour. of Dairy Sci. 40:1,338-1,342. 1957. (Journal Article 2083 from the Michigan Agricultural Experiment Station)

Hemoglobin preparations from 158 dairy cattle were examined by paper electrophoresis to determine whether multiple adult hemoglobins normally occur.

Samples from 79 Holsteins, 8 Brown Swiss, and 8 Ayrshires contained a single component designated hemoglobin A. It was concluded that the possession of hemoglobin A alone is characteristic of Holsteins.

A second, faster-migrating component, called hemoglobin F, was found in the blood of 15 of 34 Guernseys and 17 of 25 Jerseys. Both hemoglobins A and F were present in 13 of the Guernseys and 13 of the Jerseys, but hemoglobin F occurred alone in only two Guernseys and 4 Jerseys.

In all blood samples containing both types, the ratio of hemoglobin A to hemoglobin F was close to 1:1. No significant sex differences, qualitative or quantitative, were encountered. The occurrence of hemoglobin F in some adult dairy animals appears to be a normal, breed specific phenomenon.

Dormancy and Germination Characteristics of the Seeds of Four Species of Plantago

STEINBAUER, G. P. AND B. H. GRIGSBY

Proc. Assoc. Official Seed Analysts 47:158-164. 1957. (Journal Article 2086 from the Michigan Agricultural Experiment Station)

Seeds of four weedy plantains were compared as to dormancy, requirements for germination, and longevity. The species studies were two linear-leaved forms: buckhorn, *Plantago lanceolata,* and bracted plantain, *Plantago aristata;* and also two broad-leaved forms, common plantain, *Plantago major,* and Rugel's plantain, *Plantago Rugelii.*

Seeds of the first two species either have no primary dormancy or it is of short duration. Primary dormancy is much more persistent in the other two. It gradually disappears after several months of storage. It can be broken by prechill treatments.

Germination of non-dormant seeds occurred in all four species when the seeds were exposed to alternating temperatures (16 hours at 20° C., and 8 hours at 30° C.) with light during the high temperature interval, and use of 0.2 percent KNO_3 solution for moistening agent. Limited observations indicate that under some conditions, the seeds of plantains remain viable for longer periods than previously supposed.

Characteristics of Organisms Contributing to Spoilage in Cottage Cheese

BONNER, M. D. AND L. G. HARMON

Jour. of Dairy Sci. 40:1,599-1,611. 1957. (Journal Article 2087 from the Michigan Agricultural Experiment Station)

The effect of incubation temperature, pH, sodium chloride, heat, chlorine, quaternary, iodophor, and sorbic acid on the growth of 17 organisms isolated from spoiled cottage cheese was determined. None of the organisms showed growth after incubation for 3 days at 3°C. Fifteen of the 17 organisms showed growth ranging from slight to profuse after incubation for 7 days at 10°C.

Most of the organisms thrived in the pH range of 6.7 to 7.4 and, with the exception of *Torulopsis candida,* growth was retarded at pH 5.4 to 5.2 and below. Fourteen of the 17 organisms grew in 5 percent sodium chloride while only four grew in 7 percent sodium chloride.

Pasteurization at 143°F. for 30 minutes destroyed all organisms tested. Sixteen of the cultures survived 120°F. for 15 minutes in skim milk, whereas only one survived the above temperature and holding time in whey at pH 4.55.

Chlorine was the most effective germicide employed, followed by the iodophor and the quaternary compounds.

The concentrations of sorbic acid used in this work were not effective in destroying the organisms when the pH was not reduced. However, when the pH was decreased below 5.2 the viability of the cultures decreased as the sorbic acid content increased from 0.05 to 0.25 percent.

Defects Produced by Spoilage Organisms in Sterilized Cottage Cheese

BONNER, M. D.; L. G. HARMON AND C. K. SMITH

Jour. of Dairy Sci. 40:1,360-1,364. 1957. (Journal Article 2089 from the Michigan Agricultural Experiment Station)

Seventeen organisms representing five genera of bacteria, two genera of yeast, and three genera of mold were inoculated individually and in combination with *Streptococcus lactis* into cottage cheese which had been sterilized by subjection to cathode rays at a dosage of 5.5 by 10^6 rep (Roentgen equivalent physical).

Achromobacter butyri and *Achromobacter eurydice* produced gelatinous slime and a fermented aroma. *Alcaligenes metalcaligenes* and *Pseudomonas desmolyticum* produced a tapioca slime. The coliform and *Pseudomonas* bacteria, and the *Rhodotorula* and *Torulopsis* yeasts produced surface slime the characteristics of which varied with the species of organism. *Geotrichum candidum, Mucor plumbeus,* and *Penicillium frequentans* produced pigmented mold characteristic of the particular species.

Achromobacter and *Escherichia* produced defects more rapidly when inoculated individually than when combined with *S. lactis.* The yeasts and three of the *Pseudomonas* cultures produced defects more rapidly when combined with *S. lactis* than when inoculated alone. The appearance and odor of the spoiled cheese was the same, regardless of whether the cultures were introduced individually or in combination with *S. lactis.*

Most of the organisms caused increases in pH during the period required for spoilage; exceptions being the two species of *Micrococci* and the Rhodotorula yeast combined with *S. lactis* which produced acid and whey.

Hybrid Danish Willows—Their Early Survival and Growth in Michigan and Northern Wisconsin

RUDOLPH, V. J.; W. LEMMIEN, M. W. DAY, C. I. ARNOLD AND M. BAUM

Jour. of Forestry 55:887-889. 1957. (Journal Article 2090 from the Michigan Agricultural Experiment Station)

Survival and growth observations were made of imported Danish hybrid willow plantings in one northern Wisconsin and four Michigan locations. Information on parentage of the seven clones used in the plantings was not available.

Four-year survival varied from complete mortality to 78 percent. Average height in the planting with highest survival was just over 4 feet. A few surviving trees in one planting irrigated with cannery waste water were 7 feet high.

The hybrids have poor form, and appear highly suceptible to injury by frost and grasshoppers and leaf-cutting bees. Additional plantings of these hybrid willow clones should not be encouraged at this time in the Lake States.

Ethyl-3-Indoleacetate—An Artifact in Extracts of Immature Corn Kernels

FUKUI, H. N.; J. E. DEVRIES, S. H. WITTWER AND H. M. SELL

Nature 180:1,205. 1957. (Journal Article 2093 from the Michigan Agricultural Experiment Station)

Ethyl ether extracts of immature corn kernels, Zea mays, variety Golden Cross, were divided into acid and "neutral" fractions. Paper chromatographic sections of the extracts were biologically assayed. In addition to a growth-promoting and growth-inhibiting zone, 3-indoleacetic acid was detected in the acid fraction. An active neutral growth substance was observed to lack an indole moiety. This suggested that the previously isolated ethyl-3-indoleacetate was an artifact.

Some Simple Cut Indices for Predicting Carcass Traits of Swine. I. Cut-Outs and Loin Lean Area

PEARSON, A. M.; L. J. BRATZLER AND W. T. MAGEE

Jour. of Animal Sci. 17:20-26. 1958. (Journal Article 2094 from the Michigan Agricultural Experiment Station)

Results indicated that simple cut indices involving a minimum number of weights and adapted to large scale usage may be utilized in evaluation of swine carcasses. The loin index $\frac{(\textit{trimmed loin} \times 100)}{\text{rough loin}}$ appeared to be more promising than the trimmed loin-fatback ratio or the percentage of trimmed loin on either the live or carcass basis.

A comparison of the loin index and backfat thickness as measures of lean cuts (carcass basis) showed that loin index more accurately reflects percentage lean cuts.

Although percentage skinned ham and percentage New York shoulder indicated cut-out nearly as well as the various loin indices, all loin indices indicated loin lean area more accurately. On the other hand, percentage belly was a poor indicator of all cut-outs and loin lean area.

Some Simple Cut Indices for Predicting Carcass Traits of Swine. II. Supplementary Measures of Leanness

PEARSON, A. M.; L. J. BRATZLER AND W. T. MAGEE

Jour. of Animal Sci. 17:27-33. 1958. (Journal Article 2095 from the Michigan Agricultural Experiment Station)

Results indicated that the various loin indices, especially the loin index and the trimmed loin-fatback ratio, reflected the different measures of leanness or fatness more accurately than percentage ham, percentage New York shoulder, or percentage belly.

Evidence indicated that percentage trimmed loin may reflect true leanness somewhat more accurately than either of the other loin indices. Percentage skinned ham and percentage New York shoulder were more accurate indicators of the supplementary measures of leanness than percentage belly, which was of little value.

Carcass length and percentage loin were positively correlated, yet length did not influence percentage belly, percentage ham, or percentage New York shoulder, which explains the low relationship between carcass length and cut-outs.

Effects of Hyper- and Hypothyroidism on Chemical Induction of Skin Tumors in Mice

MEITES, JOSEPH

Cancer Res. 18:176-180. 1958. (Journal Article 2118 from the Michigan Agricultural Experiment Station)

In three separate experiments, the effects of feeding 2 mg. thyroxine or 2 gm. thiouracil/kg. diet on induction of skin tumors were studied in young female CF1 Swiss mice. Each mouse received one .05-ml. application over the back of 0.25, 0.50, or 1 percent of 9, 10-diemethyl-1, 2-benzathracene (DMBA), followed by once-weekly painting with 5 percent croton oil in liquid paraffin during a period of 16 or 17 weeks.

Tumor incidence per group, average number of tumors per tumor-bearing mouse, and average surface tumor area were significantly reduced in the thyroxine-fed mice and increased in the thiouracil-fed mice. These substances were most effective when the lowest dose of DMBA was used. There was little or no growth of individual tumors after first appearance in the thyroxine-fed mice, whereas most of the tumors in the controls and particularly in the thiouracil-fed mice grew in size during the period of treatment. Most of the tumors appeared to be papillomas as determined by gross and histological examination.

Food intake was greatly increased in the thyroxine-fed mice and moderately reduced in the thiouracil-fed mice. Thyroxine accelerated body growth rate for the first 10 to 12 weeks of treatment in two experiments, and for the entire 17 weeks of treatment in the third experiment in which the youngest mice were used. Thiouracil reduced body growth only in the latter experiment. Several mechanisms which may explain these results are discussed.

Natural Growth Substances in Vernalized and Non-Vernalized Lettuce Seedlings

FUKUI, H. N.; L. E. WELLER, S. H. WITTWER AND H. M. SELL

Amer. Jour. of Botany 45:73-74. 1958. (Journal Article 2119 from the Michigan Agricultural Experiment Station)

Ethyl ether extracts of vernalized and non-vernalized lettuce seedlings were fractionated into acid and "neutral" fractions. Paper chromatographic separation followed by bioassay with the Avena straight growth test demonstrated the presence of twice the amount of IAA in the acid fraction of the non-vernalized seed as compared to that which was vernalized, and two growth promoting substances in the "neutral" fractions of both the vernalized and non-vernalized seed.

Induction of Lactation in Rabbits with Reserpine

MEITES, JOSEPH

Proc. Soc. Expt. Biol. and Med. 96:728-730. 1957. (Journal Article 2131 from the Michigan Agricultural Experiment Station)

1. Twenty mature female rabbits were injected subcutaneously with 0.2 mg. estradiol daily for 2 or 10 days, followed by a single intravenous injection of 1 mg. reserpine/ kilo body weight into 10 animals. The other 10 rabbits served as controls. Nine of the 10 reserpine-treated rabbits came into lactation 1 week later while none of the controls produced milk. Four other rabbits were made pseudo-

pregnant, and 15 days later, 2 were injected as above with reserpine and 2 served as controls. Only the 2 reserpine-treated animals came into milk.

2. Macroscopic and histological examination of the mammary glands of reserpine-treated rabbits previously injected with estrogen revealed extensive lobule-alveolar development with secretion in the alveoli, whereas controls injected only with estrogen showed an extension of the duct system with no alveolar growth.

3. It is possible that reserpine induced an increased secretion and/or release of prolactin and perhaps of other hormones favorable to mammary growth and lactation, but confirmation of this hypothesis awaits assay of pituitary hormones.

Effects of Growth Hormone on Lactation and Body Growth of Parturient Rats

MEITES, JOSEPH

Proc. Soc. Expt. Biol. and Med. 96:730-732. 1957. (Journal Article 2132 from the Michigan Agricultural Experiment Station)

Twenty mature female albino rats which had reached growth status were bred. On the day of parturition, their litters were reduced to six young each.

On the fifth postpartum day, 10 rats were injected with 1 mg. GH daily for 12 days; the other 10 rats served as controls. The GH-injected rats gained an average of 2 gm. each daily during the experimental period, whereas the controls showed no increase in body weight.

The growth rate of the litters was the same in both groups, indicating that GH did not increase milk production. This contrasts with the demonstrated ability of GH to increase milk production in cattle, sheep, and goats.

Ultra High Temperature Pasteurization

KAUFMANN, O. W.

Milk Industry Found. 1957 Convention Proc. 58-61. 1957. (Journal Article 2134 from the Michigan Agricultural Experiment Station)

Ultra high temperature pasteurization is a new method of pasteurization using temperatures greater than 200° F. Milk or other dairy products pasteurized by this procedure have an extremely low initial bacteria count. Reducing the bacterial level with this high heat treatment increases the lag period of development for micro-organisms; this delayed growth results directly in an increase in the shelf life of the product.

In comparative studies, milk processed by ultra high temperature technique and held under household refrigeration conditions, kept for 24 to 27 days. Milk pasteurized at 167° F. for 16 seconds kept for 12 to 14 days.

Agriculture and the Business Cycle

HATHAWAY, DALE E.

Policy for Commercial Agriculture, Subcommittee on Agricultural Policy, Joint Economic Committee, 85th Congress, 1st Session. pp. 51-76. 1957. (Journal Article 2149 from the Michigan Agricultural Experiment Station)

This article analyzes the impact of the non-farm business cycle upon agriculture and the impact of changes in farm income upon the non-farm economy.

During periods of large expansion or contractions in the non-farm economy,

farmers' well-being has also changed substantially and in the same direction. During periods of mild expansion or contraction of non-farm business activity other factors may override the effects of changes in business activity. However, income per farm worker has increased during non-farm business expansions largely because employment was available in non-farm jobs for under-employed farm workers. Since World War II farm costs have risen more rapidly than gross farm income during every period of business expansion.

Farm output apparently is becoming increasingly responsive to changes in non-farm business activity, largely due to the increasing conformity of crop yields per acre to the business cycle.

Farmers' expenditures for current production expenses, capital items, and consumer goods appear to be related to farm income. Large increases or decreases in farm income brought similar changes in expenditures. Expenditures for capital items and consumption seemed most responsive to changes in income. These expenditures are of significant magnitude to deserve attention as a potential destabilizing influence in the economy.

American Agriculture in 1965

BONNEN, JAMES T.

Policy for Commercial Agr., Joint Econ. Committee, 85th Congress, 1st Session: 145-156. 1957. (Journal Article 2150 from the Michigan Agricultural Experiment Station)

After establishing the size and characteristics of the present chronic surplus, the future balance between production and consumption is examined. The factors that effect this balance are projected in a model and analyzed in terms of a detailed commodity-by-commodity equilibrium of consumption and production in 1965. The resource input adjustments and commodity mix for an equilibrium are specified.

The current annual production surplus amounts to about 8 percent of total domestic and export needs. The expected growth in yields and efficiency relative to population and per capita consumption indicate that this chronic production imbalance *could* easily double by 1965.

For an equilibrium such as that projected in the model, a reduction of around 11 percent in harvested acreage and a decline of 25 to 30 percent in labor force will be necessary. The number of farms in the U.S. could be expected to decline from 4.7 million in 1955 to below 4 million by 1965. The average size of farm would increase from 240 to around 300 acres over the same period.

Food Consumption Subsidies for Low Income Families

SORENSON, VERNON L.

Policy for Commercial Agriculture, Subcommittee on Agricultural Policy, Joint Economic Committee, 85th Congress, 1st Session. pp. 127-144. 1957. (Journal Article 2151 from the Michigan Agricultural Experiment Station)

In evaluating the possibility of expanding the level of domestic food consumption through subsidy programs, it must be kept in mind that the situation is quite different from that which existed when programs were inaugurated in the 1930's. Unemployment is not widespread and the general level of economic activity is high. Very few consumers are unable to buy nutritionally adequate diets if large amounts of cereal products are consumed.

Many consumers would, however, increase the proportion of animal products and fruit and vegetables in their diets if incomes increased. Since grain products constitute the major food surpluses, subsidy programs would not reduce surpluses directly. Increased consumption of animal products would result in greater utilization of feed grains.

Considering leakage which would occur, large numbers of individuals would have to be included and substantial outlays of funds would be required to increase total expenditures on food by as much as 5 percent. In view of recent increases in food requirement of about 2 percent annually due largely to population growth, this change is not spectacular. Though subsidy programs may be valid in their own right from the point of view of consumer welfare, they cannot be relied upon to solve the farm price and income problem.

(Continued from back cover)

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The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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DEZEEUW, D. J., Ph.D.....Assoc. Prof. of Botany
GRIGSBY, B. H., Ph.D.....Prof. of Botany
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KIESLING, R. L., Ph.D.....Assoc. Prof. of Botany
MURAKISHI, H. H., Ph.D.....Assoc. Prof. of Botany
NELSON, RAY, Ph.D.....Prof. of Botany
STEINBAUER, G. P., Ph.D.....Assoc. Prof. of Botany
STRONG, F. C., M.S.....Assoc. Prof. of Botany

Dairy

BRUNNER, J. R., Ph.D.....Assoc. Prof. of Dairy
HARMON, L. G., Ph.D.....Assoc. Prof. of Dairy
HEDRICK, T. I., Ph.D.....Assoc. Prof. of Dairy
HUFFMAN, C. F., Ph.D.....Prof. of Dairy
JENSEN, J. M., M.S.....Assoc. Prof. of Dairy
LASSITER, C. A., Ph.D.....Assoc. Prof. of Dairy
LUCAS, P. S., M.S.....Assoc. Prof. of Dairy
MCGILLIARD, L. D., Ph.D.....Assoc. Prof. of Dairy
SNYDER, W. W., M.S.....Assoc. Prof. of Dairy
TROUT, G. M., Ph.D.....Prof. of Dairy
WEAVER, EARL, Ph.D.....Prof. of Dairy
WILLETT, E. L., Ph.D.....Assoc. Prof. of Dairy

Entomology

MOROFSKY, W. F., Ph.D.....Prof. of Ent.
HOFFMAN, J. R., Ph.D.....Assoc. Prof. of Ent.

Farm Crops

CHURCHILL, B. R., M.S.....Assoc. Prof. of Farm Crops
DEXTER, S. T., Ph.D.....Prof. of Farm Crops
ELLIOTT, F. C., Ph.D.....Assoc. Prof. of Farm Crops
EVERSON, E. H., Ph.D.....Assoc. Prof. of Farm Crops
GRAFIUS, J. E., Ph.D.....Prof. of Farm Crops
HARRISON, C. M., Ph.D.....Prof. of Farm Crops
MOORE, H. C., B.S.....Assoc. Prof. of Farm Crops
ROSSMAN, E. C., Ph.D.....Prof. of Farm Crops
TESAR, M. B., Ph.D.....Assoc. Prof. of Farm Crops
THOMPSON, N. R., Ph.D.....Assoc. Prof. of Farm Crops
WHEELER, E. J., M.S.....Assoc. Prof. of Farm Crops

Fisheries and Wildlife

BALL, R. C., Ph.D.....Prof. of Fisheries and Wildlife
GYSEL, LESLIE, Ph.D.....
.....Assoc. Prof. of Fisheries and Wildlife
ROELOFS, E. W., Ph.D.....
.....Assoc. Prof. of Fisheries and Wildlife

Foods and Nutrition

KELLEY, A. L., Ph.D.....
.....Assoc. Prof. of Foods and Nutrition

Forest Products

WYLIE, A. E., Ph.D.....Prof. of Forest Products

Forestry

JAMES, LEE, Ph.D.....Assoc. Prof. of Forestry
ROBBINS, P. W., M.S.....Assoc. Prof. of Forestry
WHITE, D. P., Ph.D.....Assoc. Prof. of Forestry
WRIGHT, J. W., Ph.D.....Assoc. Prof. of Forestry

Home Management and Child Development

GROSS, IRMA H., Ph.D.....
.....Prof. of Home Mgmt. and Child Dev.
THORP, A., Ph.D.....
.....Assoc. Prof. of Home Mgmt. and Child Dev.

Horticulture

BEDFORD, C. L., Ph.D.....Assoc. Prof. of Hort.
BELL, H., Ph.D.....Assoc. Prof. of Hort.
BORGSTROM, G. A., Ph.D.....Prof. of Hort.
CARDINELL, H. A., B.S.....Assoc. Prof. of Hort.
CARLSON, R. F., Ph.D.....Assoc. Prof. of Hort.
CAROLUS, R. L., Ph.D.....Prof. of Hort.
DEWEY, D. H., Ph.D.....Assoc. Prof. of Hort.
HAMNER, C. L., Ph.D.....Prof. of Hort.
HANEY, W. J., Ph.D.....Assoc. Prof. of Hort.
KENWORTHY, A. L., Ph.D.....Prof. of Hort.
LUCAS, E. H., D.Agr.....Prof. of Hort.
MITCHELL, A. E., Ph.D.....Prof. of Hort.
MOULTON, J. E., Ph.D.....Assoc. Prof. of Hort.
PETERSON, C. E., Ph.D.....Assoc. Prof. of Hort.
ROBERTSON, W. F., M.S.....Assoc. Prof. of Hort.
WATSON, D. P., Ph.D.....Prof. of Hort.
WILDON, C. E., Ph.D.....Assoc. Prof. of Hort.
WITTWER, S. H., Ph.D.....Prof. of Hort.

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